NATIONAL MUSEUM OF VICTORIA

The Journal of the Department of Agriculture

VICTORIA — AUSTRALIA

VOLUME XXXII

PART 11

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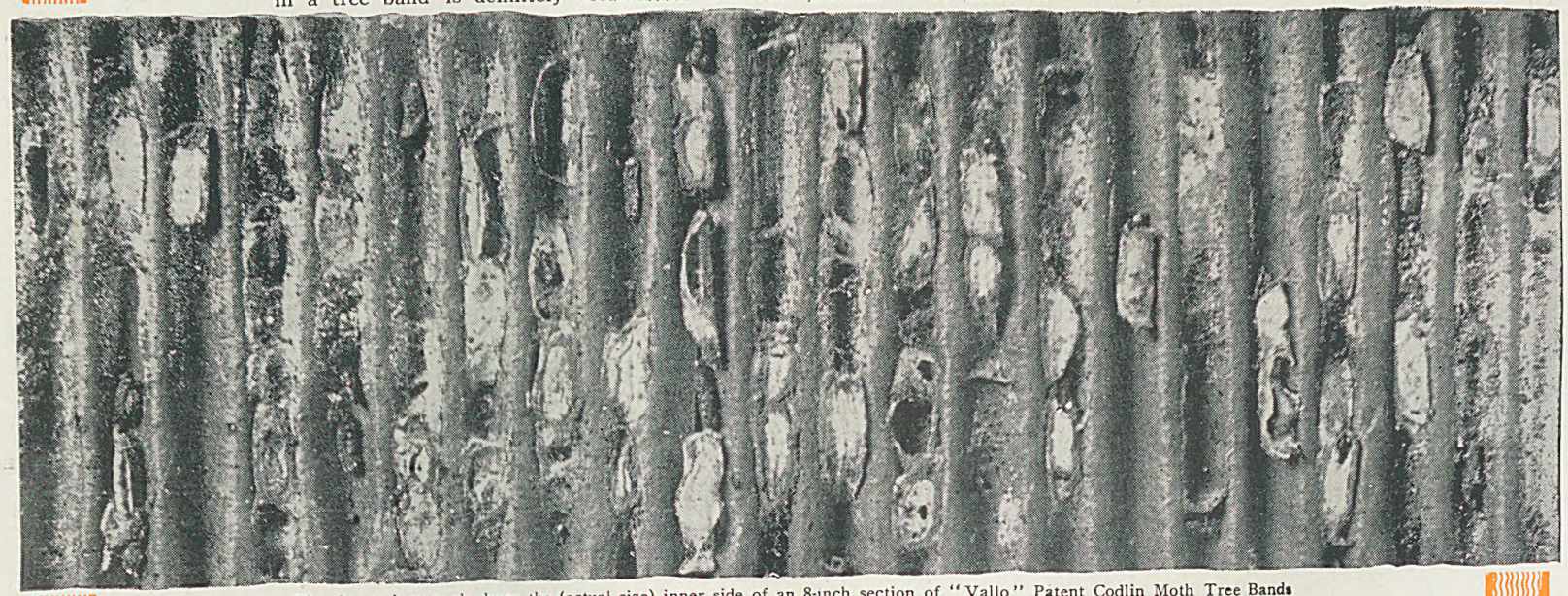

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Issued under the direction of the Hon. J. Allan, M.L.A., Minister of Agriculture.

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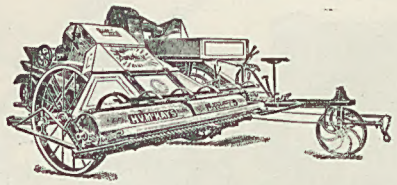

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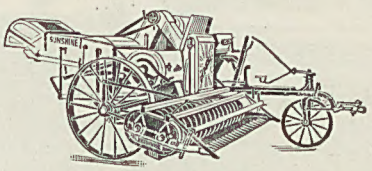

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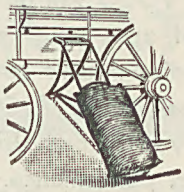

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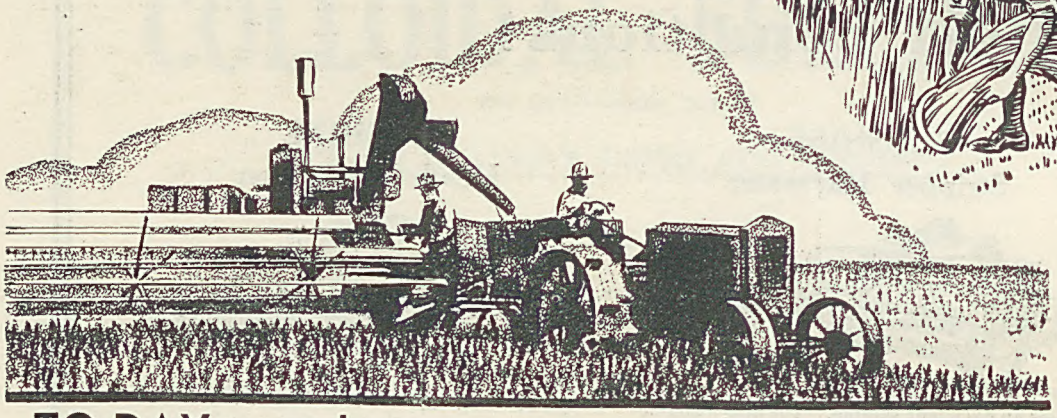

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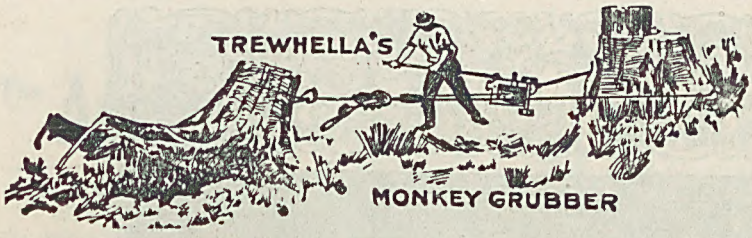

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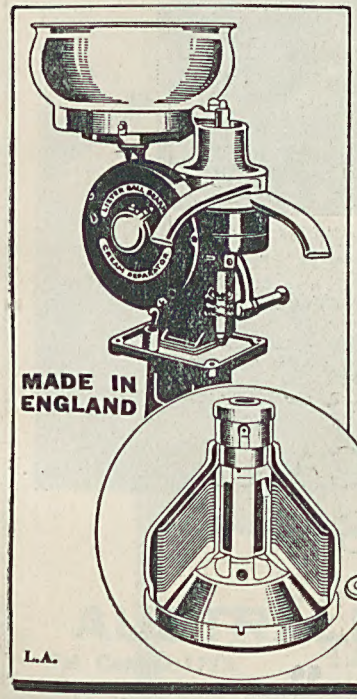

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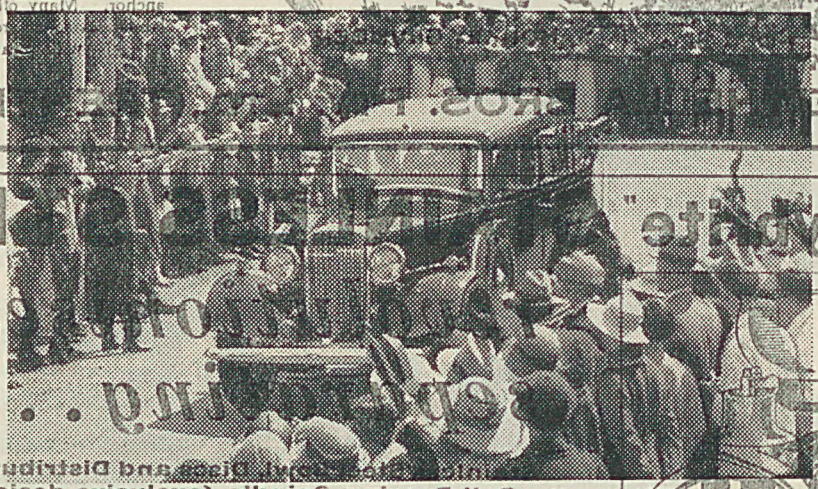

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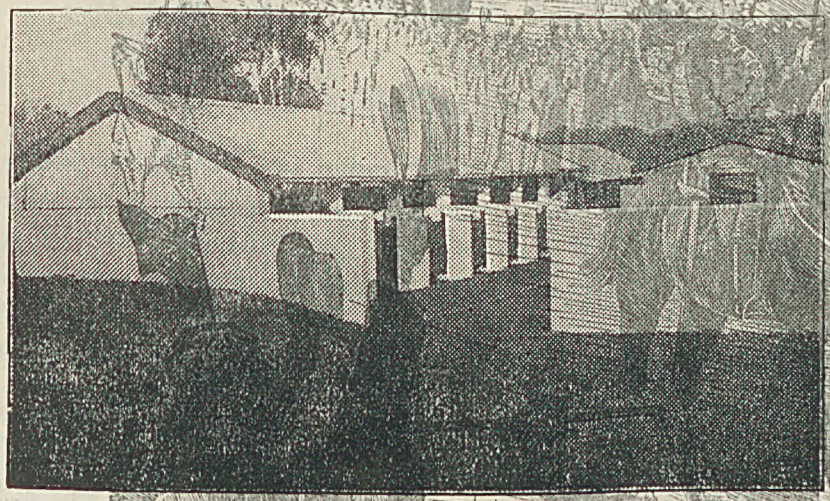

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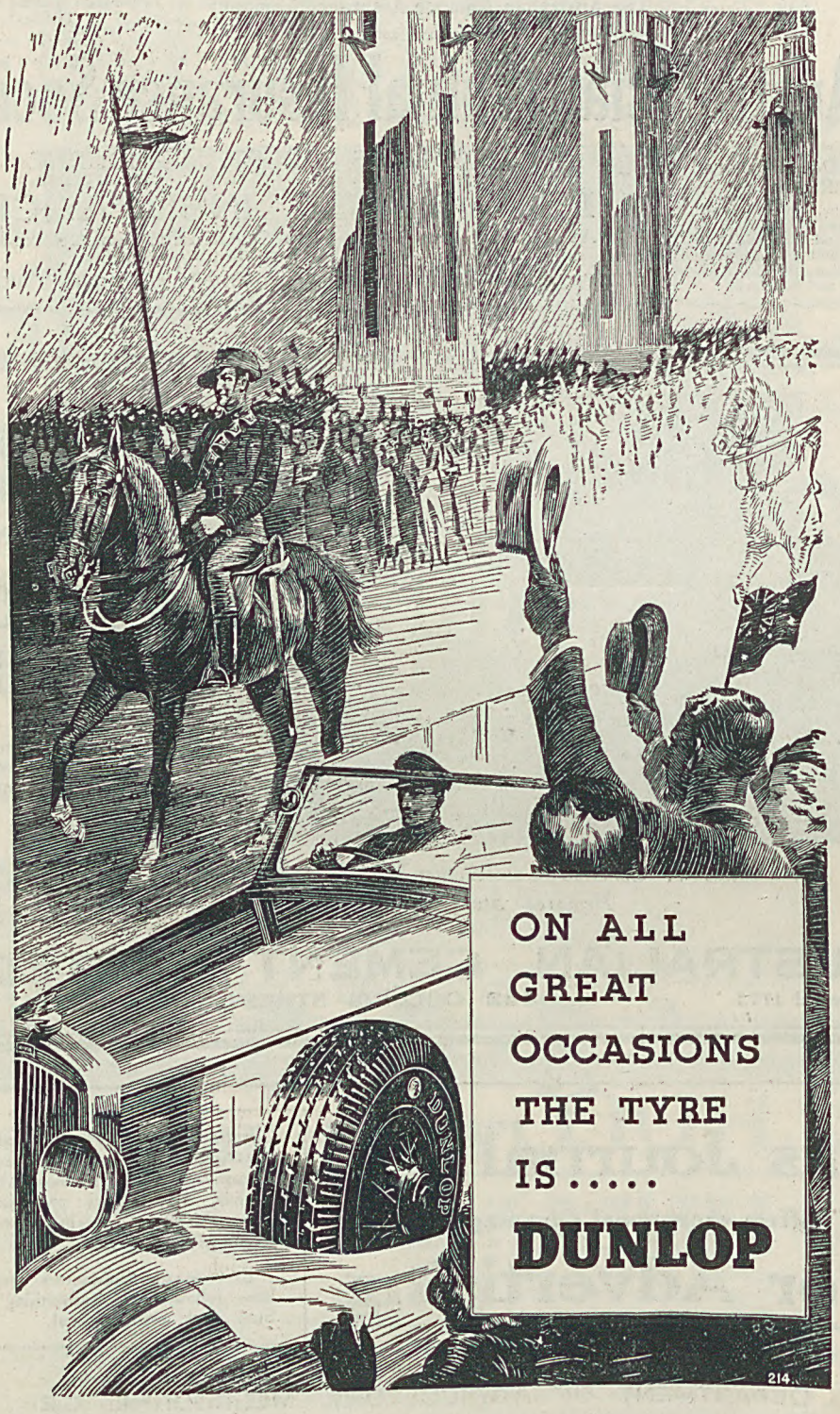
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NATIONAL MUSEUM OF VICTORIA

The Journal of the DEPARTMENT of AGRICULTURE of VICTORIA

State Research Farm, Werribee

Results of Experiments

Because of the heavy rains experienced on Thursday, 25th October, it was found necessary to abandon the annual Farmers' Field Day which was to have been held at the State Research Farm, Werribee, on Friday, 26th October. As many farmers who were in Melbourne during Royal Show week and who intended participating in the Field Day may now be unable to visit the farm this year, it has been decided to publish herewith a complete report on the results of the experimental work to date.

THE State Research Farm serves a three-fold purpose. It is a centre where farm problems can be investigated by a trained staff at the lowest cost possible to the farming community as a whole. It provides a means for the thorough testing under practical farming conditions of the experimental results obtained, and of any departures from recognized farming practice.

Thirdly, being open to inspection at all times the farm provides opportunities to make known to the farming community, by means of practical demonstration, the methods advocated in Departmental teachings.

The location has many advantages. Its frontage to the Melbourne–Geelong section of the Prince's Highway, and to the railway, renders it easy of access to, and observation by travellers, and its proximity to the Werribee railway station and to Melbourne invites inspection and facilitates co-operation with other branches of the Department which are necessarily situated in Melbourne.

The soil varies from comparatively good to definitely poor. Of the total of 2,211 acres, about 75 per cent. is volcanic clay loam overlying grey-blue pug clay, and the remainder is alluvial clay loam separated by a band of red clay from a porous silty subsoil.

GENERAL EXPERIMENTAL WORK.

The work of the farm covers as many phases of agriculture as its location, soil, and climatic environment allow. The volcanic areas are devoted to the testing of improved cereal varieties and the production of seed of outstanding varieties for general distribution. Various tillage, manurial, seeding, and disease problems which have arisen since the establishment of the permanent experimental fields are also investigated on this area. The stud cereal plots, which are the centre of the activities in regard to the hybridization and selection of new varieties, are located on the alluvial area, which is irrigable, so that in the event of drought a total loss of much valuable work may be avoided.

The alluvial area, exclusive of the permanent cereal experimental fields, is devoted almost entirely to irrigated permanent pastures of the standard perennial rye grass—cocksfoot—white

clover type, and lucerne. Lucerne was the main irrigated crop during the early development of the farm, but has been replaced almost entirely by pasture. The most generally satisfactory methods of seeding, watering, manuring, and management of irrigated lucerne have been determined, and similar work has been in progress on pasture for a number of years.

A small area of natural pasture representative of the district remains, and has been the subject of manurial and seeding experiments with the object of raising its carrying capacity.

The sheep, horses, dairy cattle, and poultry maintained on the farm have been the subject of careful investigation in regard to feeding, breeding, and productivity under varying methods of management, and good types of the particular breeds maintained may be purchased through the Department at prices commensurate with their breeding and performances.

Advanced work which has a bearing on agricultural problems and experimental methods has been contemporaneous with the work outlined above. These studies have included the investigation of soil chemistry and various organisms in regard to nitrification, plant nutrition, parasitism, and disease; the application of statistical methods to field experiments; the analysis of the factors of yield in cereals, weed control and preventive veterinary medicine.

Many problems which do not receive much publicity, such as those relating to fencing, subdivision, the disposition, construction, and equipment of sheds and stockyards, farm water supply and drainage, the construction of farm roads, have also been practically investigated, and the relative advantages and disadvantages of many systems and methods may be seen under practical working conditions at the farm.

Field Plot Technique.

In the early years of this farm the usual type of field experiment consisted of a series of single plots of each variety or treatment, the yields of which were compared with those of check plots which occurred at regular intervals throughout the paddock. This type of experimental design is to be seen in the Permanent Fields (e.g. Rotation, Manurial) and in certain of the observation plots in the main Variety Field. It is quite suitable for demonstration purposes and, when repeated over a number of years gives fairly satisfactory yield comparisons. For finer yield testing work and where results are required within a limited time, a more accurate system is necessary.

In 1927 a comprehensive review of modern methods of field experimentation was undertaken, and after some years of preliminary trials the Randomised Block system was finally adopted. In this method the varieties or treatments under tests are grouped together in one block, the necessary replication being obtained by repeating the whole block four or five times. By this means it has been possible to demonstrate significant differences of as low as five per cent.

These accurate replicated plots are used as the final yield trial in all variety and cultural tests and the results of those conducted in 1933 will be found under the appropriate sections.

Summary of Cropping, 1934.

This season, 1,350 acres are under crop, and 650 acres in winter fallow. The cropped area is made up as follows :—

Wheat for seed (bulk areas)	160	acres.
Wheat for hay	40	"
Oats for seed and hay	110	"
Barley for seed	100	"
Oats and wheat mixed, for hay	267	"
Cereals for ensilage and green feed	33	"
Field peas	10	"
	720	acres.
Irrigated lucerne	420	"
Irrigated sown grasses	210	"
Experimental plots	210	"
Total	1,350	acres.

The experimental area comprises 310 acres of which approximately 100 acres are included in the fallow above, and 210 acres are occupied as follows :—

Rotation trials	18	acres.
Green manurial and feedings tests	20	"
Permanent fertilizer tests	25	"
Seed variety, and selection plots—Wheat	56	"
Seed variety plots—Barley and oats	19	"
Miscellaneous cereal tests	12	"
Pasture top dressings	12	"
Irrigation investigations	32	"
Total area	210	acres.

The bulk cereal crops for grain comprise the following varieties :—

Wheat—Free Gallipoli, Ranee 4 H, Ghurka, Sepoy, Rajah, Mogul, Major, and Warden.

Barley—Pryor.

Oats—Algerian, Palestine, and Dawn (Sunrise selection).

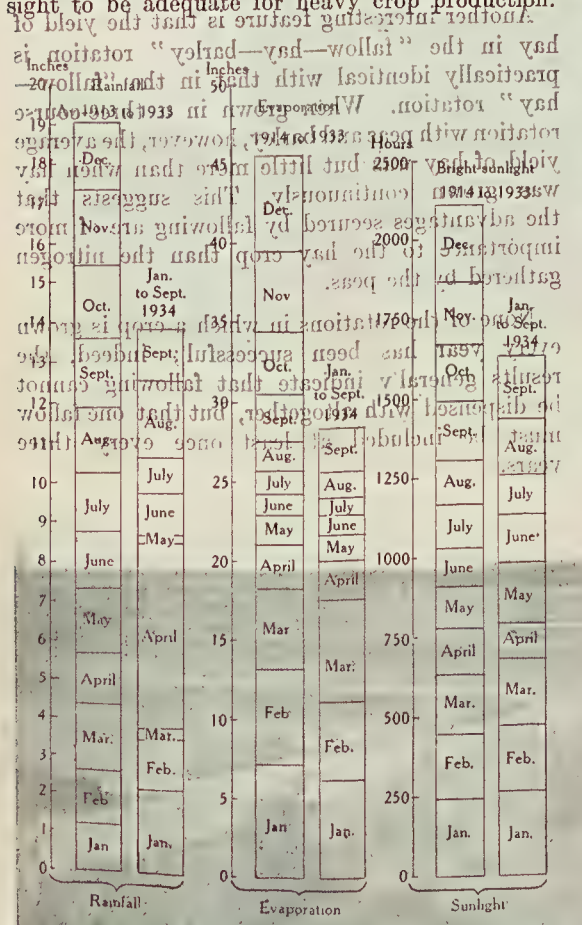
The grain obtained from these areas will be available for distribution among farmers as graded seed. Special precautions are taken to maintain its purity and trueness to type.

Seasonal Conditions.

The rainfall at Werribee for the past 50 years has averaged approximately 20 inches. Compared with the wheat belt, this rainfall appears at first sight to be adequate for heavy crop production. In point of fact, however, the rainfall at Werribee is less effective than a similar annual rainfall would be in the wheat belt of Northern Victoria.

The greater portion of the rain falls in light showers, which are frequently followed by strong winds, causing a large percentage of the moisture to be dissipated by evaporation. The average annual evaporation from a free water surface approximates 45 inches per annum. The problem of conserving moisture in the soil for the use of crops is, therefore, quite as important at Werribee as it is in the driest parts of the wheat belt of Victoria.

Conditions during the present season have been only moderately favorable to growth. The rainfall in January, February, and March was well up to the average. Heavy rains in April were succeeded by a very dry period of several months in which, also, some heavy frosts were experienced. During this time, with the surface soil very dry, growth was maintained only by occasional light showers.



Average rainfall, evaporation, and hours of bright sunlight recorded at Werribee, 1913 to 1933. The records to the end of September of the current year are shown also.

Meteorological Observations.

Meteorological observations set out below show the averages since the commencement of the farm in 1913 and for the first nine months of the current year.

	Annual Average.	Average to end of September.	Total to September, 1934.
Rainfall ..	19·20 in.	13·58 in.	13·82 in.
Bright Sunlight ..	2,097 hrs.	1,481 hrs.	1,644 hrs.
Evaporation (from free water surface)	45·12 in.	30·12 in.	28·6 in.
Air Temperatures. (Fah.)			
Dry Bulb ..	58·3°		
Wet Bulb ..	53·8°		
Maximum Dry Bulb ..	67·1°		
Minimum Dry Bulb ..	47·5°		
Mean Maximum and Minimum	57·5°		

Soil Temperatures.

Depth in Soil.	Average Annual.		
	Maximum.	Minimum.	Mean of Maximum and Minimum.
1 in.	70·1°	51·2°	58·4°
6 in.	62·0°	54·9°	58·0°
12 in.	59·9°	56·1°	58·1°
24 in.	59·2°	57·0°	58·1°

There are three fields in which the tests are of a permanent character, that is, the treatment given to individual plots is repeated, on the same piece of land, for year after year. This type of plot is particularly valuable, because certain effects which are not evident in any one season become so with the lapse of time.

Permanent Rotation Field.

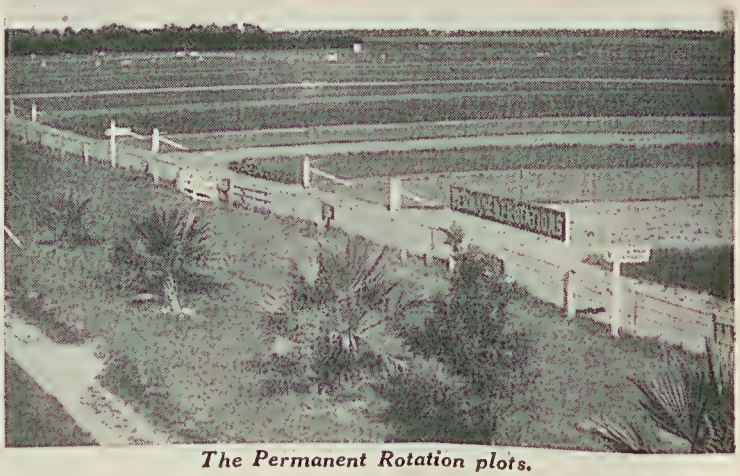
In this field there is a series of thirteen different rotations, or systems of farming. In four of them the principal crop is oaten hay, while in the remaining nine it is wheat. The treatment given each crop is, as far as possible, that of normal, good, local farming practice. Grazing results are obtained by the use of sheep, which are enclosed by temporary fences erected around the required plots.

The various rotation systems undergoing trial, together with the average yields obtained, are shown in the accompanying plan.

One outstanding result has been the marked increase in yield when either wheat or oaten hay has been preceded by a fallow. In the case of wheat the average increase was 190 per cent., and with oaten hay 83 per cent., over the stubble-grown crop. To a large extent, the reason for "wheat continuously" failing so badly is that such a system permits of an almost uncontrolled growth of wild oats, which crowds out the wheat.

Another interesting feature is that the yield of hay in the "fallow—hay—barley" rotation is practically identical with that in the "fallow—hay" rotation. When grown in a three-course rotation with peas and barley, however, the average yield of hay was but little more than when hay was grown continuously. This suggests that the advantages secured by fallowing are of more importance to the hay crop than the nitrogen gathered by the peas.

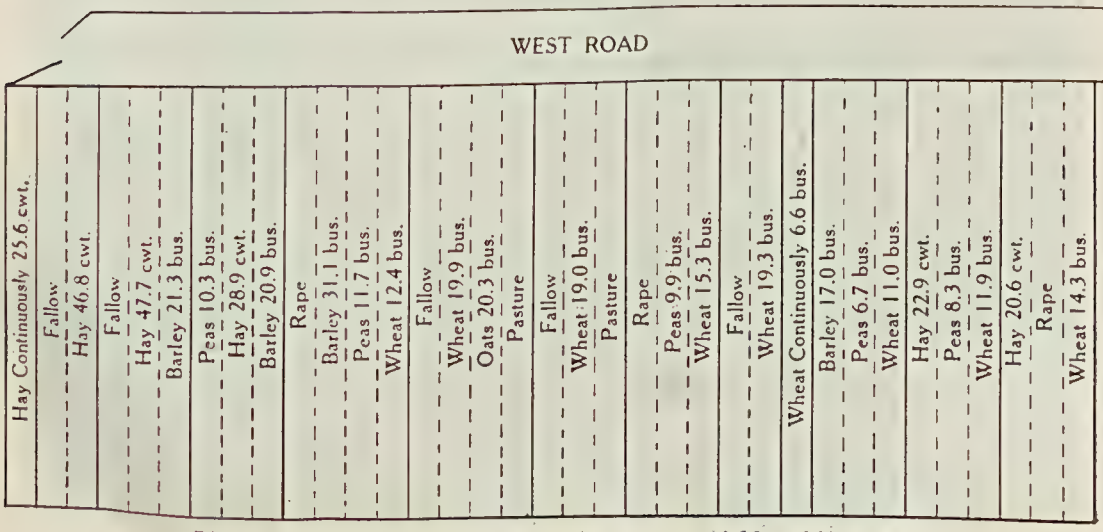
None of the rotations in which a crop is grown every year has been successful; indeed, the results generally indicate that fallowing cannot be dispensed with altogether, but that one fallow must be included at least once every three years.



The Permanent Rotation plots.

Rotation Trials—Yields of Hay from half-acre plots.

1.—Hay continuously. 2.—Hay after fallow. 3.—Hay after barley and fallow. 4.—Hay after barley and peas.



Plan of permanent rotation plots with average yields, 1913 to 1933.

Green Manurial and Feeding-off Tests.

It is of the utmost importance to the farmer that his land should have a high content of organic matter or "humus". Without it, the land is hard, cloddy, and difficult to work, and its moisture-holding capacity very poor. The common practice of alternating crop and fallow over an indefinite period is very wasteful of humus, and, if continued long enough, undoubtedly must seriously prejudice the fertility of the land.

GREEN MANURIAL TESTS—WHEAT YIELDS.

Rotation.	Average Yield per Acre.
	bushel.
Wheat after Fallow	20·2
Wheat after Rape fed off	18·6
Wheat after Barley fed off	11·3
Wheat after Peas fed off	18·8
Wheat after Oats fed off	16·7
Wheat after Rape ploughed in ..	19·2
Wheat after Barley ploughed in ..	11·7
Wheat after Peas ploughed in ..	20·6
Wheat after Oats ploughed in ..	17·4

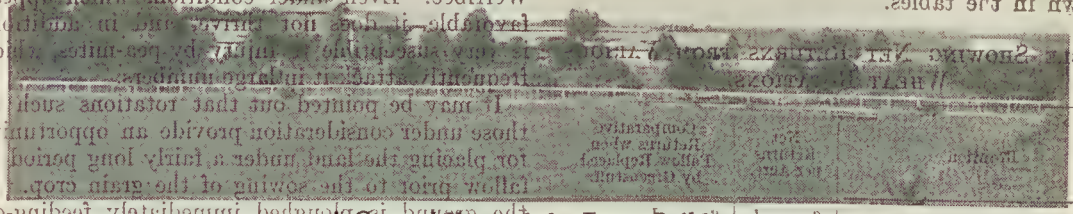
The problem then is to find a system of cropping which will be economically sound, and, at the same time, will maintain and, if possible, increase the store of organic matter in the soil. There are several possible solutions which may be considered, one of them being the application of farmyard manure. This is practicable, of course, only to the extent to which supplies of manure are available, and, in the majority of cases, these are quite inadequate. Others are the ploughing-in of a green crop, or the feeding-off of a forage crop and ploughing-in the residues.

The last two alternatives are being investigated in the tests in the Green Manurial Field, where they are being compared with the orthodox fallow. In its simplest form, this experiment necessitates the use of three plots side by side. One of these plots is in fallow; on each of the other two a forage crop is sown, which in the one case is ploughed in as soon as it reaches the required stage of growth, while in the other it is fed-off by sheep, and the residues and droppings then

GREEN MANURIAL TESTS—OAT YIELDS.

Rotation.	Grain Average Yield per Acre.	Grain and Straw Combined.
	bushel.	cwt.
Oats after Fallow	42·3	47·7
Oats after Rape fed off ..	35·0	41·1
Oats after Barley fed off ..	40·2	43·0
Oats after Peas fed off ..	35·7	45·0
Oats after Oats fed off ..	39·9	42·0
Oats after Rape ploughed in ..	36·2	45·0
Oats after Barley ploughed in ..	39·1	42·5
Oats after Peas ploughed in ..	39·6	46·7
Oats after Oats ploughed in ..	37·7	39·1

Aerial view of permanent rotation plots with irrigated pasture trial in background.



A General View of the Farm Buildings.

plough-in. The following year all three plots are sown to a grain crop, and subsequently this procedure is repeated.

In this field, tests are being conducted not with one, but with four different forage crops, viz., rape, barley, peas, and oats, while there are two grain crops, wheat and oats. A duplicate set of plots is used in order that both forage and grain crops may be shown in any one year. The fulfilling of these various requirements necessitates the use of 40 plots.

GREEN MANURIAL TESTS—GRAZING RETURNS FROM VARIOUS FORAGES WHEN PRECEDED BY WHEAT.

Crop.	Sheep Days.	Live Weight Increase.
		lb.
Rape	428	193
Barley	304	111
Peas	511	221
Oats	263	151

NOTE.—The term "Sheep Days" is used to indicate the number of sheep maintained for one day.

SUMMARY OF RESULTS.

The yields indicate that both the feeding-off and ploughing-in of green crops do maintain the fertility, and, presumably, the humus content of the soil.

2. For cereal growing under conditions similar to those at Werribee the ploughing-in of green crops is economically unsound, but increased monetary returns over the fallowing method may be secured by the feeding-off of suitable forage crops.

3. The returns from the other forage crops have been reduced by the following causes, viz., rape, general unsuitability to local conditions and attacks by pea-mites; beans, expense of the large quantity of seed required per unit area; and barley, the presence of "take-all" in the crops.

4. It is essential that the feeding-off be completed in order to secure the longest possible period in fallow.

GREEN MANURIAL TESTS.—GRAZING RETURNS FROM VARIOUS FORAGES WHEN PRECEDED BY OATS.

Crop.	Sheep Days.	Live Weight Increase.
		lb.
Rape	221	83
Barley	386	151
Peas	367	123
Oats	527	210

Stacking shandy hay.

In the following tables, comparisons are made between the financial returns from the fallowing and the green-cropping systems. In these calculations, wheat is valued at 3s. per bushel, oats at 2s., the increase in live weight of the sheep used at 3d. per lb., while an allowance has been made for wool on the basis of 7s. 8d. per year or 1d. per sheep day. The cost, over a two years' period of producing a green crop followed by a grain crop is naturally greater than that of a fallow and grain crop, since two ploughings and two lots of seed and manure are required instead of one. When estimating the respective values of the two systems, this additional cost

must be deducted from the gross returns of the green crop method to give a common basis of comparison. This gives the "net returns" as shown in the tables.

TABLE SHOWING NET RETURNS FROM VARIOUS WHEAT ROTATIONS.

Rotation.	Net Returns per Acre.	Comparative Returns when Fallow Replaced by Greenstuff.
	£ s. d.	£ s. d.
Wheat after Fallow ..	3 0 7	
Wheat after Rape, fed off	3 9 8	0 9 1 increase
Wheat after Barley, fed off	3 12 4	0 11 9 „
Wheat after Oats, fed off..	4 15 0	1 14 5 „
Wheat after Peas, fed off..	2 15 2	0 5 5 decrease
Wheat after Rape, ploughed in	1 14 6	1 6 1 „
Wheat after Barley, ploughed in	0 13 0	2 7 7 „
Wheat after Oats, ploughed in	1 8 5	1 12 2 „
Wheat after Peas, ploughed in	1 3 9	1 16 10 „

TABLE SHOWING NET RETURNS FROM VARIOUS OAT ROTATIONS.

Rotation.	Net Returns per Acre.	Comparative Returns when Fallow Replaced by Greenstuff.
	£ s. d.	£ s. d.
Oats after Fallow ..	4 4 7	
Oats after Oats, fed off ..	6 2 11	1 18 4 increase
Oats after Barley, fed off	5 6 5	1 1 10 „
Oats after Rape, fed off ..	3 19 8	0 4 11 decrease
Oats after Peas, fed off ..	3 17 2	0 7 5 „
Oats after Oats, ploughed in	2 12 5	1 12 2 „
Oats after Barley, ploughed in	2 14 11	1 9 8 „
Oats after Rape, ploughed in	2 11 10	1 12 9 „
Oats after Peas, ploughed in	2 1 0	2 3 7 „

It will be noted that barley makes a much better showing when grown in rotation with oats than with wheat. The grazing results in each case are not greatly dissimilar; the difference is to be found rather in the grain crops, as a reference to the grain tables will show. The cause of the relatively low yields in the wheat rotation is that barley, acting as a host plant to "Takeall" (*Ophiobolus graminis*) carries the disease over to the succeeding wheat crop with the result that this crop usually is badly infested with it. There is, however, some evidence that the incidence of the disease has been much lighter during the past two or three years than it had been previously.

Rape has not been a satisfactory crop at Werribee. Even under conditions which appear favorable, it does not thrive, and in addition, is very susceptible to injury by pea-mites, which frequently attack it in large numbers.

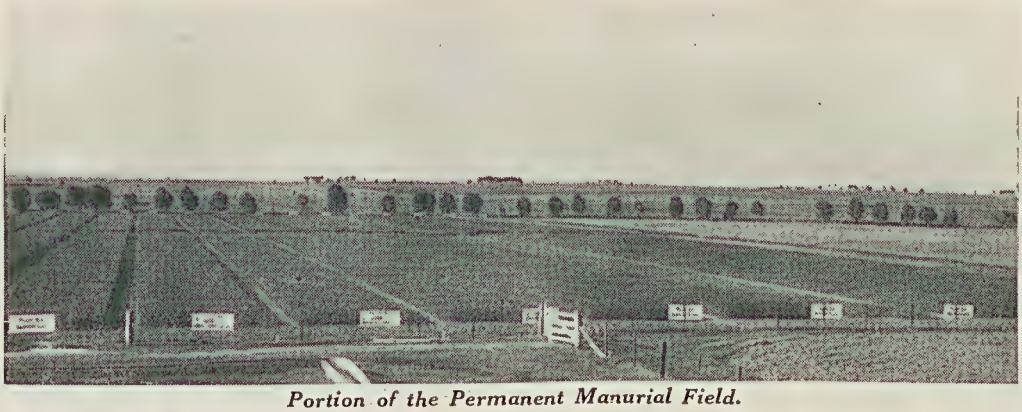
It may be pointed out that rotations such as those under consideration provide an opportunity for placing the land under a fairly long period in fallow prior to the sowing of the grain crop. If the ground is ploughed immediately feeding-off is completed, this period may easily extend to six or seven months, and there is little doubt that this fallow contributes very substantially to whatever success attends the method.

RESIDUAL EFFECTS.

If the organic matter which is being added to the soil by the turning-in of these green crops actually does enrich the soil, this effect should be reflected in increased yields of grain, unless, of course, other factors have been introduced; for instance, the green crops might deplete the soil of moisture, or, as was seen in the case of barley, diseases might be encouraged. An attempt was made in 1925 and 1926 to inquire into this aspect of the question. In these two years, the green crops were not sown, the whole of the land being laid down to fallow; the succeeding wheat crops were thus sown under similar conditions. The results given in the accompanying table, while they cannot be considered conclusive, suggest that there has been at least some increase in fertility.

AVERAGE YIELDS OF WHEAT AFTER GREEN MANURE, FOR ELEVEN YEARS (1914–24), COMPARED WITH THOSE OBTAINED ON THE SAME LAND FROM WHEAT SOWN AFTER FALLOW (GREEN CROPS OMITTED) IN THE TWO FOLLOWING YEARS (1925-26).

Rotation.	Average Yields 1914–24.	Average Yield, 1925–26.
	Bus./ac.	Bus./ac.
Wheat after Rape, fed off ..	18·2	20·7
Wheat after Barley, fed off ..	8·9	19·2
Wheat after Peas, fed off ..	18·4	21·4
Wheat after Oats, fed off ..	15·3	24·0
Wheat after Fallow	19·0	22·1
Wheat after Rape, ploughed in	18·0	19·4
Wheat after Barley, ploughed in	9·4	15·0
Wheat after Peas, ploughed in ..	19·7	19·0
Wheat after Oats, ploughed in ..	15·6	23·8
Wheat after Fallow (manured)	20·2	21·1



Portion of the Permanent Manurial Field.

Permanent Manurial Field.

There are two main sections in the permanent manurial field, one being sown to wheat and the other to oats. Two complete sets of plots are employed in each section, one being in fallow and the other under crop. In addition to these, there are two continuously cropped plots, one of which is sown with, and the other without superphosphate.

Summary of Results.

1. The relative results with wheat and oats are somewhat similar.

2. Superphosphate is the most profitable of all the fertilizers that can be applied to these crops.

3. The quantity giving the optimum results under Werribee conditions appears to be about 1½ cwt. for wheat and 2 cwt. for oats.

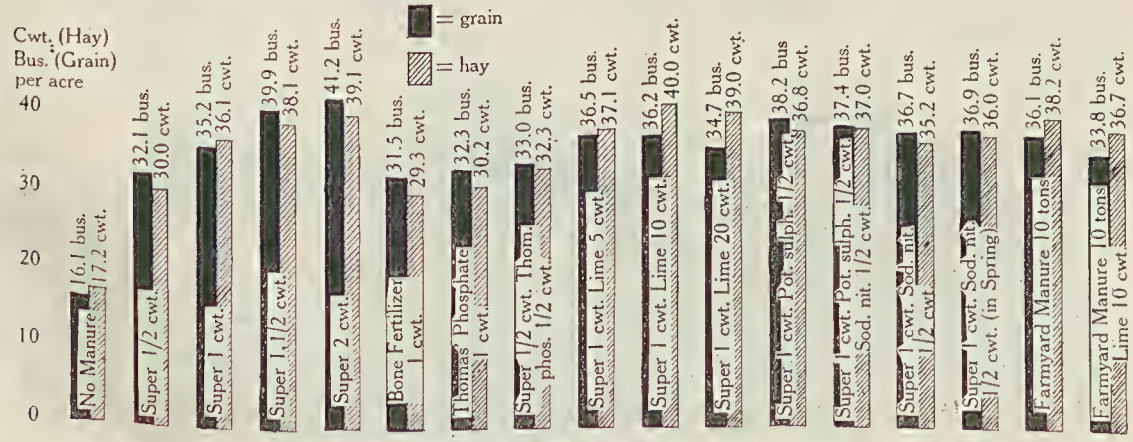
4. No profitable increase has been given either by potassic or nitrogenous manures, nor by lime in either light or heavy dressings.

The average yields of wheat and oats obtained in these trials since 1913 are shown in the Graphs 1 and 3.

The net profits from light and heavy dressings of superphosphate, bone fertilizer, and Thomas's phosphate are summarized in Graph 2, the costs of the manures being calculated at current prices and the value of wheat at 3s. per bushel.

Residual Effect of Fertilizers.

In order to ascertain the residual effect of previous dressings, the usual applications of fertilizer were withheld in 1925 and 1926. Owing to the extreme dryness of both seasons, the yields were very poor, but nevertheless distinct differences were obtained in the results. The greatest increases were shown in the plots to which superphosphate, farmyard manure, or lime had been added. The yields obtained are given in the following table.


Cwt. (Hay)
Bus. (Grain)
per acre
40
30
20
10
0
= grain
= hay
No Manure 16.1 bus. 17.2 cwt.
Super 1/2 cwt. 32.1 bus. 30.0 cwt.
Super 1 cwt. 35.2 bus. 36.1 cwt.
Super 1 1/2 cwt. 39.9 bus. 38.1 cwt.
Super 2 cwt. 41.2 bus. 39.1 cwt.
Bone Fertilizer 1 cwt. 31.5 bus. 29.3 cwt.
Thomas' Phosphate 1 cwt. 32.3 bus. 30.2 cwt.
Super 1/2 cwt. Thom. phos. 1/2 cwt. 33.0 bus. 32.3 cwt.
Super 1 cwt. Lime 5 cwt. 36.5 bus. 37.1 cwt.
Super 1 cwt. Lime 10 cwt. 36.2 bus. 40.0 cwt.
Super 1 cwt. Lime 20 cwt. 34.7 bus. 39.0 cwt.
Super 1 cwt. Pot. sulph. 1/2 cwt. 38.2 bus 36.8 cwt.
Super 1 cwt. Pot. sulph. 1/2 cwt. Sod. nit. 1/2 cwt. 37.4 bus. 37.0 cwt.
Super 1 cwt. Sod. nit. 1/2 cwt. 36.7 bus. 35.2 cwt.
Super 1 cwt. Sod. nit. 1/2 cwt. (in Spring) 36.9 bus. 36.0 cwt.
Farmyard Manure 10 tons 36.1 bus. 38.2 cwt.
Farmyard Manure 10 tons Lime 10 cwt. 33.8 bus. 36.7 cwt.

Graph 1.—Effect of fertilizers on the yield of oats.

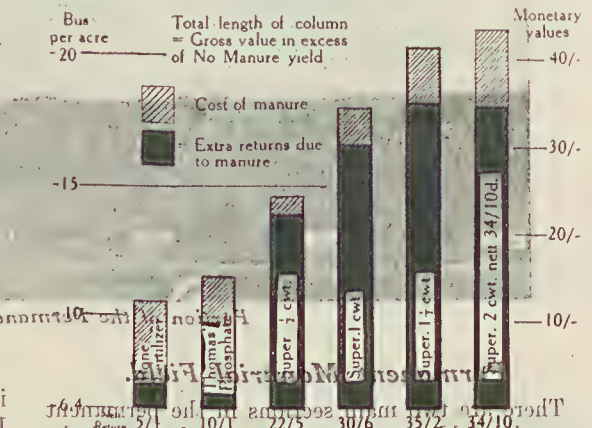
Residual Effect of Fertilizers on Yield of Wheat and Oats (1925–1926).

Application per Acre in previous Year.	Wheat Yield.	Oat Yield.
	Bushels.	Bushels.
Superphosphate, 1 cwt.	5·9	11·6
Farmyard manure, 10 tons	7·4	14·3
Farmyard manure, 10 tons, + lime, 10 cwt.	6·8	11·7
No manure	2·2	5·2
Super., ½ cwt.	2·8	7·4
Super., 1½ cwt.	7·0	11·4
Super., 2 cwt.	8·3	11·5
Super., 1 cwt., + nitrate of soda, ½ cwt. (with seed)	4·5	7·2
Super., 1 cwt., + nitrate of soda, ½ cwt. (in spring)	5·5	8·5
Super., 1 cwt.	4·8	7·8
Super., 1 cwt., + sulph. potash, ½ cwt.	4·1	7·5
Super., 1 cwt., + sulph. potash, ½ cwt., + nitrate soda, ½ cwt.	3·1	7·5
Bone fertilizer, 1 cwt.	3·5	8·6
Thomas' phosphate, 1 cwt.	4·0	8·5
Super., 1 cwt., + Thomas' phosphate, ½ cwt.	4·0	7·9
Super., 1 cwt., + lime, 5 cwt.	3·4	6·8
Super., 1 cwt., + lime, 10 cwt.	4·2	8·2
Super., 1 cwt., + lime, 20 cwt.	4·6	9·1
Super., 1 cwt.	4·6	8·4
No manure (cropped continuously)	1·5	7·3
Super., 1 cwt. (cropped continuously)	2·0	6·7

Replicated Manurial Tests.

The soil of the permanent manurial field is of an alluvial character; single plots of each treatment are employed, and each treatment has been applied to the same piece of land during the whole period of the tests.

In 1933 a complementary manurial test was carried out on a portion of the farm where the soil was a volcanic clay, and of a more typical wheat growing type. For some time, this land had been growing two crops every three years, and it is reasonable to suppose that, from the manures which had been applied to them, there would be a distinct residual effect.



Graph 2.—Comparison of net returns from light and heavy dressings of phosphates.

These variations in the conditions under which the two sets of plots were conducted, together with the fact that one of their years' duration only, probably would account for the differences in the results. The modern and more accurate system of replicating each plot several times was adopted in the trials the results of which are given herewith.

The yield from the non-manured plots is much higher than that in the permanent manurial field, while the profitable response to super ceases with the application of 1½ cwt. per acre.

Replicated Manurial Trials.—Results for 1933.

	Bushel per Acre.
No manure	21·8
Super., ½ cwt.	27·0
Super., 1 cwt.	29·2
Super., 1½ cwt.	30·0

Graph 3.—Effect of fertilizers on the yield of wheat

Nitrogen Tests on Stubble Crops.

It is known that one of the main benefits of fallowing is in the soil nitrate provided by the cultivation practice, and as might have been expected, applications of nitrogenous manures on fallow usually have failed to elicit any response.

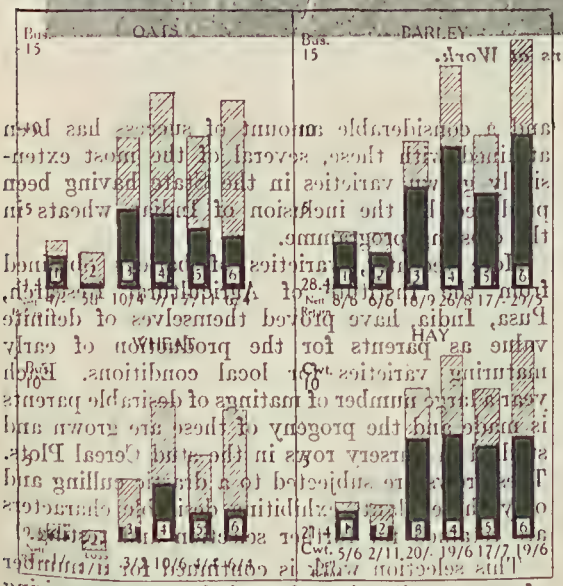
Trials were made in 1933 to ascertain the effect of nitrogenous dressings with crops sown on stubble land, the manure used being ammonium sulphate. A marked response was obtained. Owing to the heavy cost of the manure, however, careful study is required from the economic side. A comparison of the net returns is given in Graph 4. This shows that, at prevailing prices of the products and fertilizers, the following are the most profitable applications for the various cereals when sown on stubble land :—

Wheat (*grain*) Super., ½ cwt., Am. Sulph., 1 cwt.

Oats (*hay and grain*) Super., ½ cwt., Am. Sulph., ½ cwt.

Barley (*grain*) Super., 1 cwt., Am. Sulph., 1 cwt.

It should be emphasized that these results are from one season only and require confirmation by further years of testing.



Graph 4.—Results of Nitrogen Trials, 1933.

The loss-line in each case represents the cost of the manure. The profit-line represents the yield of the plots.

Treatments :—1, Super., ½ cwt., Am. Sulph., 1 cwt.; 2, Super., 1 cwt., Am. Sulph., 1 cwt.; 3, Super., 1 cwt., Am. Sulph., ½ cwt.; 4, Super., ½ cwt., Am. Sulph., ½ cwt.; 5, Super., 1 cwt., Am. Sulph., 1 cwt.; 6, Super., 1 cwt., Am. Sulph., ½ cwt.

Values :—Wheat, 3s. bus.; Barley, 3s.; Oats, 2s. bus.; Hay, £3 per ton; Super., £4 per ton; and Ammonium Sulphate, £13 per ton.

Gypsum Trials.

In certain portions of the State gypsum has proved effective in lightening the texture of heavy soils, and following the use of the material the yield of wheat on such soils has been materially increased. This experiment has been designed to test the efficacy of similar treatment on the heavy red clay loam soils of the Werribee district.

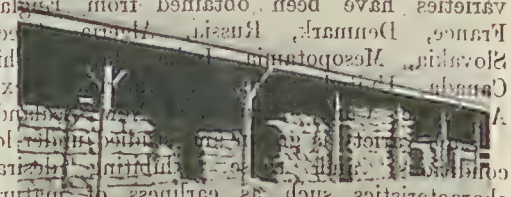
Three treatments of gypsum, ½, 1, and 2 tons per acre, are being tested against a normal control plot. The plots are grown on two sites on a wheat fallow rotation, the initial applications of gypsum having been made in October, 1930, and 1931 respectively. There has been a material improvement in texture, and this has been reflected in the yields of wheat obtained. As the following figures indicate, an increase of 6 bushels per acre has resulted from the use of 2 tons per acre of gypsum. An examination of the development of the plants showed that this increase was due in the main to the larger number of plants present on the gypsum-treated plots, i.e., a better germination in the lighter-textured soils.

The yields of wheat and the percentage germination of the various plots are shown in the accompanying table :—

Gypsum Trials.

Gypsum	Germination per Square Foot	Average Yield of Wheat per Acre
2 tons per acre	62	29·7
1 ton per acre	60	28·1
½ ton per acre	57	25·7
No gypsum	23·6	

These plots were sown in May each season with 1½ cwt. of super. and 85 lb. per acre of Free Galilee seed.



Select-bred, graded seed wheat at the Werribee Research Farm, ready for distribution to farmers.

Wheat Breeders at Work.

Cereal Breeding and Development.

The production of new superior varieties of wheat, oats, and barley by hybridization and selection, and the subsequent development and testing of these forms, provides one of the most important and extensive aspects of the research work being conducted at the farm.

A large collection of material, numbering several hundred distinct varieties of wheat, oats, and barleys, forming the basis of the breeding work, has been built up by co-operation and exchange with Agricultural Departments and Experiment Stations in all states of the Commonwealth, and in numerous overseas countries. Collections of varieties have been obtained from England, France, Denmark, Russia, Algeria, Czecho-Slovakia, Mesopotamia, India, Japan, China, Canada, United States of America, Mexico, Argentine, Chile, Peru, and New Zealand.

Each variety is grown and studied under local conditions, and those exhibiting desirable characteristics such as earliness of maturity, quality of the grain, resistance to disease, &c., are retained as potential parent forms. Particular attention has been paid to wheats which have been evolved in countries subject to arid conditions, and a considerable amount of success has been attained with these, several of the most extensively grown varieties in the State having been produced by the inclusion of Indian wheats in the crossing programme.

More recently, varieties of barleys obtained from the Institute of Agricultural Research, Pusa, India, have proved themselves of definite value as parents for the production of early maturing varieties for local conditions. Each year a large number of matings of desirable parents is made and the progeny of these are grown and studied in nursery rows in the stud Cereal Plots. These rows are subjected to a drastic culling and only those plants exhibiting desirable characters are retained for further selection and testing.

This selection work is continued for a number of years until only a few of the more promising true breeding strains of the original population are left. These are then grown in seed multiplication plots (Long Rows) and finally pass to the larger field plots for accurate testing to determine their yielding capacity.

The Stud Cereal Plots cover an area of approximately ten acres, and this year comprise some 6,600 rows.

The work of cereal breeding has many aspects which may be briefly summarized as follows :—

(*a*) Wheat: Breeding for yielding capacity, resistance to disease, milling, and baking quality.

(*b*) Oats: Breeding for yielding capacity, resistance to disease, milling quality.

(*c*) Barley: Breeding for yielding capacity, resistance to disease, malting quality.

(*a*) Wheat.

(I.) *Breeding for Yield.*

This involves the inherent yielding capacity of the parent varieties as well as such accessory characters as drought and disease resistance, capacity to hold the grain at maturity and so on. The main objective has been the production of prolific drought resistant varieties suitable for the various districts of the State, and in this direction considerable success has been achieved. In the 1933 season 2,628,945 acres or 82 per cent. of the wheat area in Victoria was sown with varieties which originated at the State Research Farm, Werribee, and, in addition, several of these wheats are finding a place in the wheat growing areas in other States.

Six main varieties produced at the farm have been made available to farmers. These may be briefly described as follows :—

Free Gallipoli : A mid-season wheat which has proved its adaptability to a wide range of conditions. It is now the most extensively grown wheat in the State.

Ranee 4H : An early mid-season variety which is particularly suited to the drier areas of the wheat belt. Ranee 4H has now replaced the original variety Ranee, which it outyielded by an average of 3.9 bushels per acre in numerous tests extending over a number of years. It is now second in popularity in Victoria.

Ghurka : A short strawed, mid-season, drought resistant variety, adapted to a wide range of conditions. Resistant to flag smut.

Sepoy : A late maturing variety which has yielded exceptionally well in the Mallee.

Rajah : An early maturing, drought resistant variety particularly suited to the drier areas of the state. The original strain of Rajah has been superseded by a later strain which holds its grain better and which also gives consistently higher yields.

Mogul : A mid-season variety which has given particularly good results in the central and north-central districts. Over the past ten years at Werribee this variety has outyielded all others by two bushels per acre.

Typical Free Gallipoli Ears.

The rapidity with which these wheats have displaced the older varieties is indicated by the following table :—

Distribution of Werribee Bred Wheats.

Year.	Acreage Sown in Victoria.	Percentage Total Area.
	acres.	%
1925	66,000	2
1926	195,000	6
1927	507,000	16
1928	1,000,000	25
1929	1,480,000	41
1930	2,680,393	56
1931	2,116,599	66
1933	2,628,945	82

Note.—The statistics as to the varieties sown were not collected by the Government Statist in 1932.

The farm is particularly suited to the production of drought resistant varieties, and the Departmental plots located at twelve centres scattered throughout the wheat belt are especially valuable in indicating the suitability or otherwise of the new crossbreds to various districts.

"Yield" Factors and the "Census" Study of Varietal Differences.

The yield of any crop is controlled in the first instance by two factors, (1) number of ears, and (2) average weight of ear. Analysing these factors still further, we find that "yield" may be expressed as the product of four main factors:—

Yield (Y) — No. of ears — No. of plants (*p*); No. of ears/plant (*e*)

Yield (Y) — Av. Wt. per ear — No. of grains/ear (*n*); Av. Wt. per grain (*g*)

If by any method a value can be obtained for each of these factors in any experiment with varieties or manures, &c., it becomes possible to determine not only "why" certain varieties are better than others, but also "how" such increases are obtained. By means of this information varieties then may be classified into groups exhibiting desirable characters of, say, large number of heads, or weighty grain, &c., and thus a guide is given in the breeding and selecting of new wheats.

A study of all the plants in any crop becomes an impossible task when many experiments are to be studied, so that some system of examining certain small portions scattered over the whole area is essential. As a result of these studies, begun in 1927, explanations of many rather incomprehensible facts have been suggested. The crops are examined at three stages of their growth:—

(*a*) At germination, when the samples are marked and the number of germinating plants counted;

(*b*) in September, to obtain a measure of the vegetative growth in the number of stools formed per plant; and

(*c*) at harvest, when the number of ears, number of grains per ear, and weight of grain are determined.

The following table gives some typical results:—

Average Figures for the "Yield" Factors.

——	Rajah.	Ranee.	Free Gallipoli.	Federation.
(*p*) Plants/foot ..	9·25	8·83	8·11	7·02
(*e*) Ears/plant ..	1·30	1·60	1·36	1·44
(*n*) Grains/ear ..	20·0	14·8	17·2	17·3
(*g*) Weight/1,000 grains	33·6	35·8	37·3	30·2
(Y) Yield (bus./ac.) ..	22·2	22·4	20·2	16·0

The relatively low number of plants per foot of Federation will be noticed. This variety has suffered in most years from a fairly high percentage infection of "foot-rot," which has decreased the number of plants maturing at harvest. The figures for the number of ears per plant show that Ranee, in spite of its comparative earliness, matures a large number of ears per plant, which however tend to be small in size when compared with the large head of Rajah. An outstanding feature of the table, as shown by the weights per 1000 grains, is the large grain of Free Gallipoli when compared with Federation. The final "yield" figures show the material increase of all three new types, Rajah, Ranee, and Free Gallipoli, over the standard Federation, achieved in each case by a superiority in a different "yield" factor.

A study of the relation of the number of stools produced in Spring to the number of heads matured at harvest has provided results of interest. Those varieties which can produce from a given quantity of vegetative spring growth the greatest number of ears at harvest should tend to be more economical in food and water requirements, and therefore may be more drought resistant than other types. Thus it is possible that the figure of "percentage survival" of ears and stools may be a direct measure of drought resistance. The figures for the above four varieties at Werribee are as follow:—

Average Figures for "Percentage Survival" of Ears and Stools.

——	Rajah.	Ranee.	Free Gallipoli.	Federation.
No. stools per plant ..	2·37	2·92	2·89	3·38
No. ears per plant ..	1·30	1·60	1·36	1·44
"Percentage Survival"	55%	55%	47%	43%

It is significant that all the new varieties which have proved themselves superior to Federation in the drier districts of the State show a material increase in this "survival" figure.

Information of this character is thus of value not only in designing a scheme of crossbreeding to obtain combinations of desirable characters, but also as a definite guide in the most important work of selection in the progeny of these crosses. Dependence solely on yield as a guide to selection in the early stages when pure lines are still being grown in small rows is apt to be misleading, therefore it is of advantage to be able to recognize

the characters associated with high yield while the varieties are in this early stage. The "census" analysis of yield has been extended to include many other trials not only with wheat but also with barley and oats, and in this manner the interpretation of the action of rates of seeding, manuring, and other allied problems has served a most useful purpose.

(II.) *Breeding for Disease Resistance.*

Special attention is being devoted to the production of prolific varieties which will be resistant to one or more of the various fungus diseases which take their annual toll of the wheat crops. This aspect of the work necessitates the growing and testing of the new crossbreds in a special disease nursery (the quarantine field) where every grain is inoculated with the specific disease prior to sowing. The main aspect of this work is the production of varieties of wheat resistant to flag smut (*Urocystis tritici*) which probably causes greater losses to the grower than any other disease. Some 50 standard varieties are being tested annually to determine their reaction to the disease and in this way resistant forms have been isolated. These are being used as parents for mating with the more prolific but susceptible varieties with the object of combining the desirable characters, disease resistance and prolificacy, in the progeny.

Investigations at the farm have indicated that the character for resistance is heritable and further work is in progress to determine the actual mode of inheritance, as it is realized that such knowledge will greatly facilitate the breeding of new forms.

At the present time more than 800 crossbreds are undergoing infection tests in the quarantine area, and some of these which have successfully resisted the disease for three years are being grown in the "Long Rows" and "Selection Plots" this year.

It is worthy of note that two Werribee productions (Ghurka and the crossbred Rajah x Gallipoli) exhibit a high degree of resistance to flag smut.

Efforts are also being directed toward the production of varieties resistant to loose smut (*Ustilago tritici*), and, in this regard, the variety Forward, which is resistant to the disease, but which is a poor yielder, has been mated with the more prolific but susceptible local varieties.

(III.) *Breeding for Milling and Baking Quality.*

Improvement of the milling and baking qualities of Victorian wheats, by hybridization and selection, provides one of the most important phases of the breeding work. A collection of the highest quality wheats available in the world is being built up, and the more promising of these are being used as parents for mating with the best yielding Australian forms, in an attempt to produce new varieties combining the three desirable characters—quality, flour colour, and prolificacy.

Section of the Quarantine Area.
This is an isolated area where cereals from overseas are grown under observation, and new crossbreds, &c., are tested for disease resistance.

This work entails much testing both in the field and in the laboratory where the latest chemical methods are adopted to determine the inherent quality of each crossbred. Some hundreds of new crossbreds are at present undergoing intensive trial in this regard.

(*b*) Oats.

(I.) *Breeding for Yield.*

In the case of oats the main objective has been the production of prolific drought resistant varieties suitable for hay or grain. In addition, attention is being directed to the breeding of varieties suitable for early green feed. Up to the present two varieties—Palestine and Dawn have been evolved at the farm. Palestine is a very early maturing, short strawed, drought resistant variety which has given exceptionally high yields of grain over a wide range of conditions. Dawn, a selection from the variety Sunrise, though somewhat later in maturity than the parent, is still earlier than Algerian in this respect. In addition it is stronger in the straw than Sunrise, and in the green stage has proved particularly palatable to stock.

(II.) *Breeding for Disease Resistance.*

Attention is also being devoted to the breeding of varieties of oats which will be resistant to the two diseases—Loose Smut (*Ustilago avenae*) and Covered Smut (*Ustilago levis*). For this purpose,

resistant varieties have been obtained from America and are being mated with the local high yielding forms. The progeny will be tested for resistance by a method similar to that adopted for testing for flag smut resistance in wheat.

(III.) *Milling Quality.*

In recent years a great deal of attention has been paid to the production of varieties especially suited to the requirements of the milling trade, and all new crossbreds are subjected annually to a close examination to determine their suitability in this respect.

(c) Barley.

(I.) *Breeding for Yield.*

The breeding programme in regard to barley embraces the improvement of both malting (two-rowed) and feed (six-rowed) types. During the past few years more than 150 new varieties of barley have been imported, mainly from those barley countries of the world which lie between the same parallels of latitude as Victoria.

The object of these importations is to secure early maturing forms which may be used as parents with the local varieties for the breeding of superior new varieties suited to the Victorian environment. Earliness of maturity is regarded as essential under Victorian conditions in order to enable the plant to escape the hot northerly winds which take their toll of the crops during the latter portion of the season, and which result in decreased yields and inferior grain samples.

Among the imported forms, three are outstanding on account of their earliness of maturity. These were obtained from India, and have been extensively used in the crossing programme.

The three main aspects of the work of improving yielding capacity refer to malting barleys, feed barleys and skinless barleys. In addition attention is being directed towards the production of smooth awned barleys, with the object of eliminating the objectionable, rough, barbed beard so characteristic of the common varieties. In all some 700 new crossbreds are undergoing trial in the Stud Cereal Plots.

(II.) *Breeding for Disease Resistance.*

Varieties which are resistant to the common smuts of barley—Covered Smut (*Ustilago hordei*) and Loose Smut (*Ustilago nuda*) have recently been obtained from Europe and are now being used as parents for mating with local varieties.

(III.) *Breeding for Malting Quality.*

Particular attention has been paid to the production of new varieties combining earliness of maturity, yielding capacity, and superior inherent malting quality. Barleys obtained from England and Czecho-Slovakia have proved to be superior in regard to inherent malting quality and some of these have been mated with local varieties, and with the early maturing Indian forms mentioned above. From the progeny of these matings, numbering some hundreds of thousands of plants, three or four hundred distinct lines have been isolated and are at present undergoing trial in the Stud Cereal Plots. It is expected that a few of the more promising of these will be included in the variety field trials in 1935.

Recent developments in the barley breeding work at the farm have made it possible to produce three generations of plants each season. In order to achieve this a special bird-proof cage, equipped with electric light, has been constructed, in which the extra generations are grown during the summer and autumn months. The first generation is raised between early December and the end of January under natural daylight conditions. By supplementing the normal daylight with electric light a second generation may be grown between the end of January and mid June. The third generation can then be grown under field conditions during the period June to December. This speeding up of growth is applied only to crossbred material, and is responsible for the saving of two years in the time required for the production of new crossbred barleys.

Threshing Barley from the variety plots.

Description of Plots Employed.

Stud Plots.—The stud plots consist of 6,600 rows, each from 5 to 20 yards in length. These form the nursery for new crossbreds and selected plants. Single plant testing is the basis of the work, and, to make this practicable, seeding is done by hand, the seeds being dropped singly several inches apart. Crossbreds remain in these plots until at least the fourth generation.

(2) *Long Rows.*—There are 640 long rows, each 5 chains in length. In these are sown the most promising types from the stud plots. The rows are sown singly, about 3 feet apart, with an ordinary seed drill, the spacing being obtained by closing the necessary number of grain runs. The yields of grain are measured and recorded from this stage onward.

(3) *Selection Plots.*—The selection plots represent the next step in production. The 280 plots sown this year are each 5 chains in length, and from 3 to 4 feet in width, and are separated from one another by about the same distance, the intervening space being kept cultivated.

(4) *Variety Plots.*—The variety plots consist of 66 single type plots, and 299 replicated plots, covering 74 varieties. They are grown under conditions which, for the first time in the process of testing, approximate those of ordinary field crops.

(5) *Seed Plots.*—The 33 seed plots are each about 2 acres in area and are used solely for the purpose of seed multiplication. Only those standard and crossbred varieties which have shown superior yielding capacity are admitted to these plots. Before sowing, the seed is subjected to the Tapke hot-water treatment for the prevention of loose smut, and then, before harvesting, the crop is carefully examined and all foreign varieties removed. The seed from these plots is used to sow the bulk areas from which is produced the grain distributed to farmers.

Crossing two wheats.

Crossbred wheats under test in "Long Rows."

Seeding the bulk plots.

The yields of some of the more successful varieties shown in the accompanying tables represent the respective degrees of suitability of the varieties to Werribee and similar districts :—

Wheat Variety Trials.

Variety or Pedigree.	Average Yield. (Ten Years)
	Bushels per acre.
Mogul	27·1
Currawa x Major x Gallipoli	25·4
Ranee x Rajah	25·2
Sepoy	25·1
Free Gallipoli	25·0
Ranee	24·7
Ghurka	24·7
Rajah	24·3
Major	24·0
Federation	21·4
Yandilla King	20·5
Warden	19·1

Replicated Wheat Variety Trial, 1933.

Method.—Five blocks of four and eight varieties respectively, each plot 1/40th acre in area.

Variety.	Yield.
Early Section.	Bushels per acre.
Improved Gluyas x Ranee	30·2
Ranee	29·8
Rajah	29·0
Ranee x Gallipoli	25·6

Notes.—For significance, differences must exceed 1·1 bushels per acre.

The Ranee x Gallipoli cross-bred definitely failed during this season.

Variety.	Yield.
Late Section.	Bushels per acre.
Sepoy x Gallipoli	32·9
Gallipoli 70 G	32·0
Major x Ranee	31·4
Ranee x Gallipoli W.5806	31·2
Free Gallipoli	30·5
Ranee x Gallipoli W.5899	29·8
Cu x Ind. E x Tels.	29·3
Mac's White x Glencope	27·0

Notes.—For significance, differences must exceed 1·0 bushel per acre.

Only the first two varieties on this list significantly outyielded the standard Free Gallipoli in 1933.

OAT VARIETIES.

Oat Variety Trials—(Average Yields for Four Years, 1930–33.)

Variety or Pedigree.	Grain.	Grain + Straw.
	Bushels per acre.	Cwt. per acre.
Wild Oat x Ruakura x Kanota, W5010K 9	55.2	51·9
Wild Oat x Ruakura x Kanota, W5011K 6	55.0	51·6
Wild Oat x Ruakura x Kanota, W5011K 19	47.6	52·7
Palestine	44.2	38·0
Wild Oat x Ruakura	43.9	49·6
Lincoln Algerian	43.8	51·9
Mortgage Lifter	43.4	50·7
Richland	43.1	50·1
Mulga	39.6	..
Sunrise	39.4	41·9
Algerian	37.7	48·3
Lachlan	32.8	40·2
Dawn	32.1	45·6

Some results from variety tests with hay are shown in the following table :—

Oaten Hay Tests.—(*Average Yields,* 1929–1933).

Variety or Pedigree.	Cwt. per Acre.
Wild Oat x Ruakura ..	51·3
Algerian	48·5
Dawn	46·6
Mulga	46·3
Sunrise	46·6
Palestine	41·1

Miscellaneous Tests.

Rate and Time of Seeding Trials.

The object of these trials is to determine the influence of the rate and time of seeding on yields of wheat and oats.

Varying conditions, in both types of test, have been observed from time to time, but the results have been practically the same on all occasions. With both crops best results have been obtained from a seeding of approximately 80 lb. per acre.

Early sowing, especially with oats, has given substantially increased yields over late sowing. Late varieties, which require a long-growing period, should be sown before early varieties.

Field Peas.

During the past two years, some attention has been given to the growing of field peas on fallow. Variety and rate of seeding tests have been included in a series of replicated plots. The varieties tested were Dun and White Brunswick. The former is well known. White Brunswick has been grown for some years in South Australia, but is comparatively new to Victoria. The straw is dwarf in habit of growth and the seed white in colour and much smaller than the Dun; it also ripens at least two weeks earlier. Three rates of seeding have been tested, in which the number of seeds per foot of drill row have been respectively 3·5, 4·5, and 5·75. Last season the quantities of seed per acre required to give these various spacings were obtained by the use, in the case of the Dun, of 120, 156, and 200 lb., and of the White Brunswick, of 104, 135, and 174 lb. The size of the peas, and, consequently, the number required for any desired seeding, varies considerably from year to year.

Stripping the "Long Row" wheats.

On this occasion, White Brunswick proved much superior to Dun, while, with both varieties, the heaviest rate of seeding gave the highest yield.

The mean results per acre from eighteen plots are shown hereunder :—

Variety Tests.	bushels.
White Brunswick	24·3
Dun	19·8
Rate of Seeding Tests.	bushels.
3·5 seeds per foot	20·7
4·5 seeds per foot ..	22·0
5·75 seeds per foot ..	23·6

The differences in all the above cases are significant. It should not be forgotten, however, that, in comparisons between an early and a late variety, such as those under notice, some particular set of weather or other conditions might unduly favour one at the expense of the other; the results obtained on this occasion must therefore be qualified to that extent.

Plant Diseases.

Observations on Flag Smut.

An interesting observation from the work in the wheat sections of the permanent manurial field is that the conditions brought about by the application of lime and farm-yard manure apparently favour the development of Flag Smut.

Inheritance of resistance to Flag Smut in Wheat.
Row 1—Resistant, Rows 2 and 3—Susceptible to disease. The three selections are the progeny of a mating between Nabawa (resistant) and Indian H (susceptible).

During the past few years, Flag Smut has been noticed in increasing quantities in this field, where the rotation practised is wheat-fallow-wheat-fallow. In 1927, counts were made of the percentage infection with the disease on various plots in the field. These counts were repeated in 1928 and 1929.

Results.

Manurial Treatment.	Infection Per cent., 1927.	Infection Per Cent., 1928.	Infection Per Cent., 1929.
Super. 1 cwt.	0·9	3·7	2·1
Farmyard Manure, 10 tons	6·9	17·0	9·7
Farmyard Manure, 10 tons + Lime, 10 cwt. ..	14·7	28·8	18·5
No Manure	1·9	4·4	2·2
Super., ½ cwt.	..	2·2	2·2
Super., 1½ cwt.	..	2·2	1·5
Super., 2 cwt.	..	2·7	1·0
Super., 1 cwt. + Lime, 5 cwt.	7·6	10·9	10·4
Super., 1 cwt. + Lime, 10 cwt.	13·4	14·4	11·9
Super., 1 cwt. + Lime, 20 cwt.	13·2	11·3	10·0
Super., 1 cwt.	3·2	4·0	3·5

Wheat Pickling Plots.

These plots were conducted for several years in order to compare the respective merits of the wet and dry methods of pickling as used for the prevention of Bunt or Stinking Smut. The tests were confined mainly to determining the effect of the pickling on the germination, growth, and subsequent yield of the treated seed.

Later, trials were conducted to determine the comparative efficacy of the various brands of commercial dry pickling powders. Further trials were made to determine also the value for bunt prevention of other copper compounds not generally used for this purpose.

Counts made upon the field germination of wet and dry pickled seed have shown the dry pickled seed to give regularly a better and more vigorous germination than that of the wet pickled seed. This improved germination and early growth usually is reflected in a small increase in yield, the average results over the six years having been as follow:—

Treatment.	Yield.
	Bushels per Acre.
Bluestone, 1¼ per cent. solution—3 mins.	10·3
Formalin, 1–450—3 mins.	10·4
Copper Carbonate, 2 oz. per bushel ..	11·3

Both the wet and dry treatments give complete and effective control of the disease when applied to ordinary smut-infected seed.

Treatment for Loose Smut.

For many years the prevalence of loose smut ("blow smut") in wheat has given farmers considerable concern.

In 1927 apparatus was installed at Werribee for the purpose of testing the efficiency of a hot water treatment devised by Dr. Tapke in America.

As the table given below indicates, immersion for 1 hour 40 minutes in water held at 120 deg. F. has given satisfactory results in controlling the disease. The accompanying table

gives, in a precise form, the results obtained to date :—

Treatment.	Total Smutty Heads per 1/20 Acre.			Average.
	1927.	1928.	1929.	
Untreated ..	1,603	585	75	754
1 hour, at 120° F. ..	64	155	37	85
1 hour 20 minutes, at 120° F.	27	56	0	27
1 hour 40 minutes, at 120° F.	3	2	1	2

As the tests have shown that the treatment of the seed for periods of 1 hour 40 minutes or longer has been effective in controlling the disease, steps are taken every year to treat the more important varieties at various stages as they are grown in the experimental fields.

Dry Pasture Trials.

The investigation of means of improvement of the natural pastures of the district was initiated in 1924 when a top-dressing trial was laid down. The results over a period of years, which are given in the following table, showed no improvement in sheep days or live weight increase from an annual top-dressing of 2 cwt. of super.

It is evident, therefore, that the particular strain of Wallaby Grass which is the major pasture grass

Top-dressing Trials, Werribee—Average, 9 Years.

Treatment.	Number of Sheep Days.	Net Gain in Live Weight.
2 cwt. super. ..	341 per acre per annum	23·0 per acre per annum
No manure ..	320 per acre per annum	24·0 per acre per annum

on the Werribee plains does not respond to superphosphate under these climatic conditions. This pasture further does not permit the natural invasion of annual clovers as a result of top-dressing, an important feature which has been observed elsewhere.

It is apparent that the pasture improvement programme should progress along the lines of the introduction of drought resistant species of grasses and clovers which are known to respond to superphosphate. Such a further trial was initiated in 1930, and was designed to test the establishment and behaviour of three types of plant associations which have shown promise—

(*a*) A seeding of a mixture of Wimmera Rye and lucerne on fallow (6 lb. of each constituent with 1 cwt. super.).

(*b*) A seeding of Wimmera Rye and Subterranean Clover on fallow (6 lb of Rye and 2 lb. Sub. Clover, with 1 cwt. super. per acre).

Aerial view of the farm buildings.

(*c*) A seeding of the Wimmera Rye and Subterranean Clover mixture with 1 cwt. super. per acre as a top-dressing on the natural pasture, sown with the drill points in the ground.

The cost of establishment of the two former types is in the region of £2 per acre, while that of the third type is as low as 12s. per acre. In all cases subsequent top-dressing has been at the rate of ½ cwt. of super. per acre per annum.

The pastures which are now in their fifth year are grazed at regular intervals, and records are kept of the number of sheep days from each type as compared with the natural pasture in an adjacent area. Estimates of the percentage composition of the pastures from a species point of view, are taken at regular intervals.

The results to date serve to indicate the possibilities of such pasture types under Werribee conditions. The carrying capacity of the association described under (*b*) above has been at the rate of over two wet sheep per acre for the last four seasons, a considerable improvement on the natural pasture, which carries only one sheep or less per acre as a wool-growing proposition. There is every prospect of the pasture resulting from the sowing of these species, Wimmera Rye and Subterranean Clover, direct into the natural pasture without preliminary cultivation finally reaching the same productivity but the development is rather slower.

Good as these pastures are they have the weaknesses of those constituted mainly of annuals, namely, a late start in the autumn, a comparatively early finish in the spring and no response to summer rains. It is possible to overcome these by the use of perennial grasses, and in 1933 establishment tests of the following mixtures were sown on fallow—

(*a*) *Phalaris tuberosa* and Subterranean Clover.
(*b*) Cocksfoot and Subterranean Clover.
(*c*) Perennial Rye Grass and Subterranean Clover.

These swards are now in their second season and their development is being observed closely from the point of view of both the grazing provided and the persistence of the various species.

Hoary Cress Control Tests.

After a series of tests extending over the period 1926-30, it has been ascertained that under Werribee conditions a complete eradication of patches of hoary cress (*Lepidium draba* L.), is possible by means of a series of shallow cultivations at intervals of not more than fourteen days, carried out regularly for a period of two years. Cultivations not in accordance with this system are, however, dangerous, in that they tend to distribute pieces of the root-system over a large area, causing a widespread infestation.

Of the sprays tested at Werribee, 6 per cent. arsenic pentoxide solution applied at the rate of about 120 gallons per acre proved most effective. The weather conditions prior to spraying, and the soil moisture available to the plants at the time of spraying, were found to exert a considerable influence on the efficiency of the spray. When plants growing under conditions of low soil moisture were sprayed, at the rate specified, after a week of hot, dry weather, a good control was obtained. Owing to variations in the amount of soil moisture available to treated plants, 100 per cent. efficiency of the spray cannot be obtained, the best control noted being 93 per cent. of the plants for a period of twelve months after spraying.

Hoary Cress plant and flower.

IRRIGATION INVESTIGATIONS.

An area of 33 acres is reserved for irrigation experiments as follow :—(*a*) Watering and manurial tests on pasture, (*b*) grazing trials on old lucerne converted to pasture, (*c*) rotational grazing trials on old pasture, and (*d*) nitrogenous manuring and frequency of cutting tests. The earliest irrigation tests at the Farm were almost entirely confined to the determination of the best methods of watering, cutting, manuring, and renovation of lucerne, and, at the same time, several imported strains of lucerne were subjected to trial by comparison with Hunter River lucerne.

Lucerne thrives well under irrigation at Werribee, and yields up to 6½ tons per acre have been obtained in favourable seasons. Two hundred acres of land on the farm was sown to this crop. This area was graded, and is divided into a series of "bays" by a system of parallel check banks running in the direction of the greatest slope of the land. The "bays" are from 5 to 10 chains long, and from two-thirds to 1 chain wide. The slope of the land averages 2 inches to the chain. The water used is derived by gravitation from the Exford Weir and Pyke's Creek Reservoir.

The following results were obtained from the earlier lucerne experiments which were carried out from 1919 to 1924 :—

(1) *Rate and Frequency of Watering Tests* : Considering the results of two seasons 1921–22 and 1922–33, there was an increased production as the amount of irrigation water applied was increased, but the increase was not proportional to the added amounts of water. The non-irrigated plot gave a yield of 29.7 cwt. of hay per acre. The first 18 inches of irrigation water produced an increase of 90.3 cwt. ; the second 18 inches of water only 33.1 cwt. ; 24 inches of water increased the yield by 112.1 cwt., while an additional 24 inches of water gave a further yield of only 23.7 cwt.

All the evidence goes to show that 24 inches of water in six applications of 4 inches is the best rate of irrigation for lucerne, having regard to the economy of watering, yield, quality, and longevity of the lucerne stand.

The yield per acre-inch of water shows a successively diminishing return from the lighter to the heavier waterings. Eighteen inches of water was insufficient for full development of the lucerne even when applied in six lots of 3 inches.

To maintain favourable moisture conditions for lucerne at least 24 inches of water in addition to the average rainfall is required, although this amount does not set a limit to profitable irrigation. The efficiency of the 24 inches of water depends on the method of application. Six waterings of 4 inches (yield 141.8 cwt.) were better than four waterings of 6 inches (yield 134.4 cwt.) or eight waterings of 3 inches (yield 129.3 cwt.).

Generally, the results of the later lucerne tests (1925 to 1931) confirmed those of the earlier experiments. Although there had been a succession of dry seasons (as evidenced by the very low average yield, for four years, of 9.2 cwt. per acre from the No Irrigation Plot), six waterings of 4 inches again proved the best method of irrigating lucerne.

The soil in the irrigated section is not very porous and approximately only 2 inches of water is absorbed at an initial application. Hence, six ordinary waterings of 2 inches yielded only 45.2 cwt. of hay per acre over a four years period, while an extra inch of water at each irrigation (six waterings of 3 inches) gave an average yield of 81.4 cwt. These results demonstrate that the more penetrating waterings are more efficacious in the proper development of lucerne than even a greater number of lighter waterings.

It was proved also that, on non-porous soils, increased absorption of water could be achieved more economically by the use of supplementary waterings one or two days after the original application, than by the use of heavy applications of a soil amendment such as gypsum, or by subsoiling.

Waterings in excess of 4 inches gave heavier yields during the first two seasons, but the lucerne rapidly thinned out on these heavier-watered plots, with considerable diminution of yield in the ensuing seasons. The plot receiving six waterings of 4 inches yielded as heavily in the third and fourth seasons as it did in the second, 106 cwt. of hay per acre being the yield in each season.

In the watering tests, 2 cwt. of superphosphate per acre per annum was applied throughout.

(2) *Spacing of Rows Test.*—This test comprising four plots was designed to test the influence on seed production of distances varying from 7 inches to 28 inches between the rows of lucerne. Each season the lucerne was allowed to go to seed, and the quantity of seed produced from each plot determined. However, the attempt to produce seed at Werribee was a failure.

(3) *Time of Cutting Test.*—Three treatments were investigated, viz., (*a*) cut before blooming, (*b*) cut one-tenth in bloom, and (*c*) cut in full bloom. From the lucerne cut before blooming, six cuts were obtained in the season; from that cut one-tenth in bloom, five cuts; and from the cut in full bloom, four cuts. The heaviest yield, 121.7 cwt. of hay per acre, was obtained from the lucerne cut when one-tenth in bloom. The lucerne cut before blooming yielded 108.5 cwt. and that cut in full bloom 117.1 cwt.

The quality of the hay at the "one-tenth in bloom" stage is very good, though not quite as good as that obtained when cut before blooming, As the bloom develops, the lucerne deteriorates in quality, and, when in full bloom, the stems are coarse and woody, the leaves are dropping, and the shoots of the new crop are well forward. In the first and last cuts of the season, when the period of ripening is somewhat irregular, the percentage of bloom is not a very reliable guide as to the best time of cutting. At such times a much better indication is the appearance of the young shoots of the succeeding crop.

(4) *The Renovation Tests* were designed to demonstrate any benefits from the scarifying of lucerne. As well as control plots which received no cultivation, some plots received a winter cultivation, while others received a winter and summer cultivation.

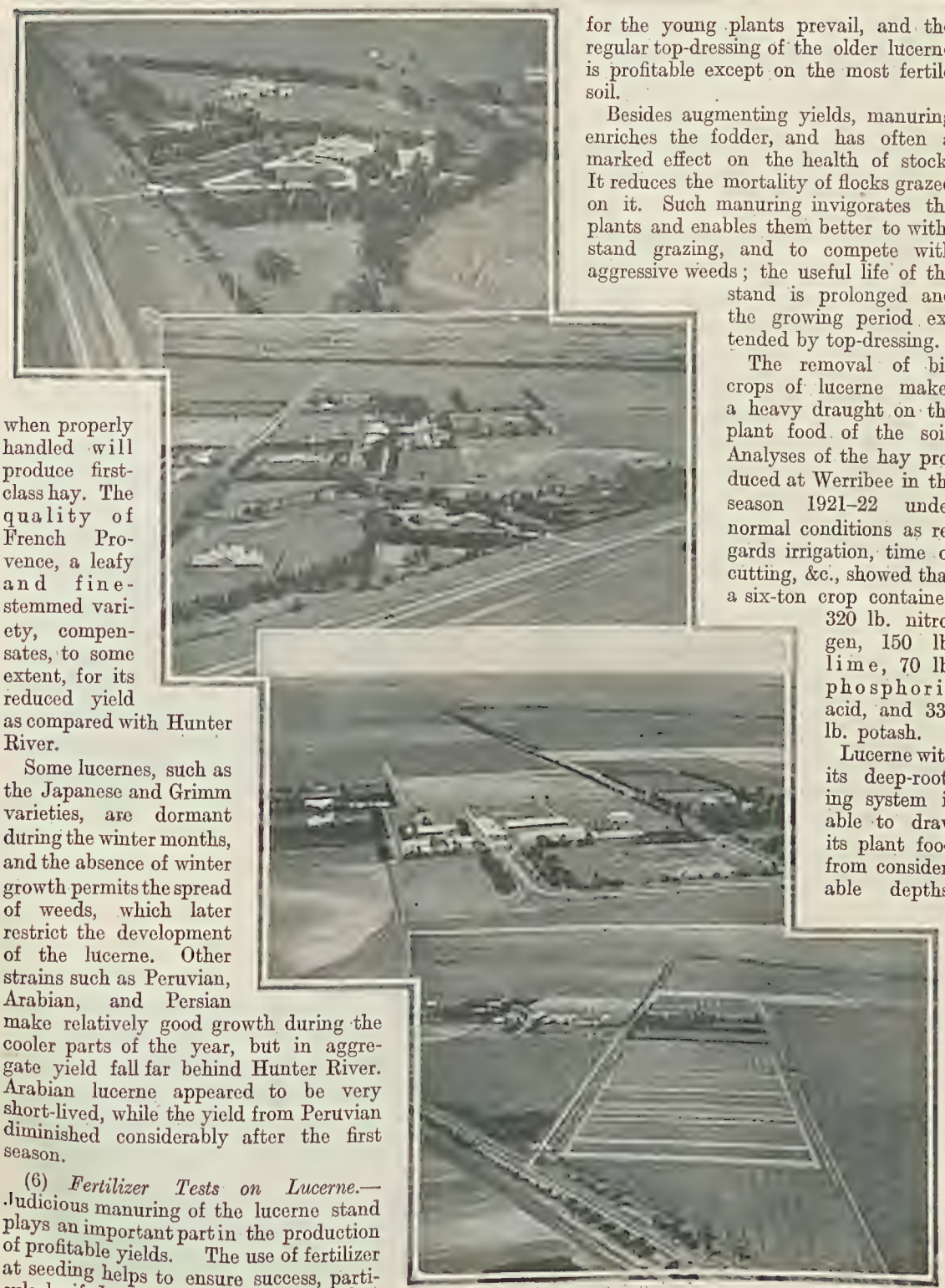
The results did not disclose any benefit from the scarifying. Irrigated lucerne which is liberally top-dressed with superphosphate and consequently free from weeds, does not require cultivation, and the density of the lucerne will not be impaired. The only result from the scarifying was a reduction in the amount of annual grasses in the first cut.

(5) *Variety Trials.*—To ascertain the variety best adapted to conditions similar to those at Werribee, some imported strains were tested in comparison with Hunter River lucerne, an acclimatized Australian variety which occupies the greater part of the lucerne areas of the State. Although there are no well-defined botanical differences between most of the cultivated varieties, they exhibit characters which differentiate them, and some are adapted for particular conditions. They show considerable variation in their powers of production.

Generally, Hunter River lucerne is recommended on account of its productivity, its longevity, and its ability to make moderate growth during the winter months.

In the earlier tests, all varieties failed by comparison with Hunter River lucerne. In the later tests, Marlborough, a New Zealand strain resembling Hunter River, was the only one which compared favourably with that variety.

In respect of quality, Hunter River is somewhat inferior to some of the varieties tested, but



Aerial views of the Farm.

when properly handled will produce first-class hay. The quality of French Provence, a leafy and fine-stemmed variety, compensates, to some extent, for its reduced yield as compared with Hunter River.

Some lucernes, such as the Japanese and Grimm varieties, are dormant during the winter months, and the absence of winter growth permits the spread of weeds, which later restrict the development of the lucerne. Other strains such as Peruvian, Arabian, and Persian make relatively good growth during the cooler parts of the year, but in aggregate yield fall far behind Hunter River. Arabian lucerne appeared to be very short-lived, while the yield from Peruvian diminished considerably after the first season.

(6) *Fertilizer Tests on Lucerne.*—Judicious manuring of the lucerne stand plays an important part in the production of profitable yields. The use of fertilizer at seeding helps to ensure success, particularly if dry or unfavourable conditions for the young plants prevail, and the regular top-dressing of the older lucerne is profitable except on the most fertile soil.

Besides augmenting yields, manuring enriches the fodder, and has often a marked effect on the health of stock. It reduces the mortality of flocks grazed on it. Such manuring invigorates the plants and enables them better to withstand grazing, and to compete with aggressive weeds; the useful life of the stand is prolonged and the growing period extended by top-dressing.

The removal of big crops of lucerne makes a heavy draught on the plant food of the soil. Analyses of the hay produced at Werribee in the season 1921–22 under normal conditions as regards irrigation, time of cutting, &c., showed that a six-ton crop contained 320 lb. nitrogen, 150 lb. lime, 70 lb. phosphoric acid, and 335 lb. potash.

Lucerne with its deep-rooting system is able to draw its plant food from considerable depths,

and at Werribee very high yields have been obtained even without manure, but still the use of fertilizers has induced extra returns considerably in excess of the cost of application.

Experiments have been carried on at the Werribee Research Farm for several years to test the influence of fertilizers applied in varying quantities and in different combinations. The results have served to emphasize the value of the soluble phosphatic manure, superphosphate and the unprofitableness of using nitrogenous or potassic manures on lucerne.

Superphosphate is the most effective manure, and 2 cwt. per acre is advocated as an annual top-dressing. However, as much as 4 cwt. of superphosphate, which would replace all the phosphoric acid removed, may be profitably used.

Top-dressing with gypsum appears to be more advantageous than equivalent amounts of calcium in the form of ground limestone or burnt lime. Both potassium sulphate and sulphur fail to produce increased returns at Werribee. Insoluble phosphatic manures, rock phosphate basic slag, and bone fertilizer fail to produce results comparable to those obtained with superphosphate.

IRRIGATED PASTURES.

Prior to 1914, only 5 acres of irrigated grasses and clovers had been sown in the Werribee district, and that was on the Research Farm. To-day, in the Werribee district alone, there is a total of approximately 4,000 acres of irrigated pasture. On the Research Farm, 400 acres, the major part of the irrigated area, has been laid down in permanent mixed pastures which have been sown down to replace the lucerne as it thinned out. These pastures have proved suitable for irrigated conditions, and when looked after are very productive, long-lived, and, at the same time, palatable to stock. Further, pastures have demonstrated that they are much better adapted for grazing than lucerne.

The mixture generally sown on the Research Farm is as follows :—

	per acre.
Perennial rye grass	12 to 14 lb.
Cocksfoot	3 to 5 lb.
Alsike clover	1 to 2 lb.
Perennial red clover	1 to 2 lb.
White clover	1 to 2 lb.
Strawberry clover	¼ lb.
Subterranean clover	1 to 2 lb.
Totals	20 to 27 lb.

The first mixture, i.e., 20 lb. per acre, is usually ample, provided the soil conditions at seeding are satisfactory. The mixture may be modified to include 2 lb. of prairi grass, a valuable winter-growing species, or 1 to 2 lb. of lucerne per acre.

Importance of Strain.—It is recommended that only proved persistent strains of the above grasses and clovers be sown, particularly in the case of perennial rye grass, cocksfoot, and white clover. Such strains are exemplified by Certified New Zealand Hawke's Bay strain, and seed marketed by the Colac Rye Grass Growers' Association in the case of rye grass; by the Akaroa strain and the best strains of Victorian grown cocksfoot, and by New Zealand certified wild white clover.

The rate and frequency of watering, manurial, and variety tests laid down in 1925 correspond to those conducted with lucerne, but, while hay yields are a suitable measure for the production of lucerne under varied treatments, the production

Weighing the produce from the irrigated pasture tests.

from pasture is not so easily determined. Determination of sheep-carrying capacity together with yield-sampling of the pasture before and after grazing, and yields of herbage from close mowing at frequent intervals are the methods adopted and they give satisfactory results.

Steel quadrat used in making botanical surveys.

As far as possible, at each mowing or yield-sampling, botanical analyses of the pasture are made to obtain a picture of the changing composition. The percentage estimation method is adopted. Results of the botanical analyses are applied to the results of the yields obtained by mowing or sampling and thus the productive powers of the various pasture plants and their relative palatability are determined.

Rate and Frequency of Watering Tests.—In these tests the plots are ¼ acre in area. During two seasons, 1929 to 1931, the plots were mowed, five sections of 1/40th acre in each plot being cut. The manurial treatment was uniform for all plots, viz., 2 cwt. super. per acre. During the first season the herbage from each plot at each cut was sampled and chemically analysed.

A record of the yield of clippings from three sections of each plot, reduced to a dry basis, is given, but the yields must be considered in conjunction with the table summarizing the botanical composition of the herbage growing on the different plots.

Irrigated Pasture—Rate and Frequency of Watering Tests.

Summary of results, Seasons 1929–30 *and* 1930–31 (*pounds of dry matter per* 0.075 *acre*).

Watering Treatment.	Season, 1929–30.	Season, 1930–31.
6 waterings of 3 inches ..	504·4	634·1
6 waterings of 4 inches ..	690·2	741·4
6 waterings of 5 inches ..	655·3	734·1
6 waterings of 6 inches ..	684·4	701·3
No irrigation	218·0	281·6
5 waterings of 6 inches ..	543·5	649·2
4 waterings of 6 inches ..	530·2	682·5
3 waterings of 6 inches ..	431·9	643·5
8 waterings of 3 inches ..	624·2	710·1

Table showing Botanical Composition of Herbage on Different Plots.

Waterings.	Average per cent Rye-grass.	Average per cent. Cocksfoot.	Average per cent. White Clover.	Average per cent. Subterranean Clover.
6 of 3 inches	7·9	26·7	38·2	14·2
6 of 4 inches	5·1	18·5	60·6	10·9
6 of 5 inches	6·4	17·4	55·9	16·6
6 of 6 inches	10·9	14·4	64·5	8·8
5 of 6 inches	7·8	21·7	45·4	19·2
4 of 6 inches	9·4	18·7	27·7	31·4
3 of 6 inches	8·9	16·7	24·7	33·1
8 of 3 inches	7·5	15·3	62·5	11·0

Conclusions.

(1) Two acre-feet of irrigation water gave the highest yield.

(2) This amount of water is best applied in six waterings, rather than in four or eight waterings.

(3) Six waterings of 4 inches gave a higher yield per acre-inch of water applied than any other watering treatment.

(4) Seasonal distribution of growth was better in the case of the frequently watered plots.

(5) The preponderance of subterranean clover in the infrequently watered plots limited production in the summer months.

(6) The dominance of white clover on the frequently watered plots gave sustained high production during the summer.

(7) The pasture on the plot receiving six waterings of 4 inches was relatively well-balanced in respect of grasses and clovers, and white clover and subterranean clover.

(8) Waterings in excess of 4 inches are not desirable on frequently irrigated pasture when 2 cwt. super. per acre has been applied.

An examination of the results of the chemical analyses showed that the herbage from all the irrigated plots was of a highly nutritious character.

During season 1931–32 the plots were grazed intermittently by sheep. Yield samples were cut before and after grazing, dried, cleaned, and when weighed, were chemically analysed. Although the schedule of watering could not be completed during this season owing to heavy rainfall in the late summer and autumn, the results generally confirmed those obtained under mowing in the two previous seasons.

The fodder analyses showed that the nutritive value of the portion of the herbage eaten by the sheep was of a higher order than the herbage removed by the mower. During the season the total area carried nine sheep per acre per annum.

Rate and Frequency of Watering Tests, with superimposed Manurial Treatments.—In 1932 a test was commenced on the rate and frequency of watering plots to determine whether extra superphosphate or supplementary nitrogenous manure would vary the efficiency of the different watering treatments when compared with the results obtained from applying the original dressing of 2 cwt. super.

On half the plots, eighteen sections were made in each bay, and this permitted of six replicates of the three manurial treatments, arranged in randomized blocks.

The plots were closely mown at intervals during the season of 1932–33, and the yields of clippings reduced to dry matter, are shown in the accompanying table :—

IRRIGATED PASTURE—RATE AND FREQUENCY OF WATERING TESTS, 1932–33 (WITH SUPERIMPOSED MANURIAL TREATMENT).

Summary of Yields (pounds of dry matter per 1/45 acre).

Watering Treatment.	Manurial Treatment.		
	Super., 2 cwt. per acre.	Super., 4 cwt. per acre.	Super., 2 cwt. +3 dressings of Amm. Sulph. 1 cwt./acre.
6 waterings of 3 inches	138·1	152·3	145·9
6 waterings of 4 inches	153·2	167·5	159·4
6 waterings of 5 inches	153·8	171·3	159·5
6 waterings of 6 inches	147·9	161·3	146·5
No irrigation ..	43·2	45·8	46.2
5 waterings of 6 inches	129·4	135·3	132·0
4 waterings of 6 inches	112·5	119·3	118·1
3 waterings of 6 inches	103·3	108·4	110·0
8 waterings of 3 inches	127·9	138·3	133·7
Totals ..	1,109·3	1,199·5	1,151·3

Although only one year's results are available the following tentative conclusions may be drawn :—

(1) The use of extra superphosphate significantly increased the yield of the *frequently* watered plots.

(2) The relatively smaller increases in yield induced by the nitrogenous manure do not justify the considerable expense of its liberal application.

(3) Pasture which is *infrequently* irrigated does not benefit materially from the increased use of super. or the addition of nitrogenous manure.

Manurial Trials.—This original section consists of duplicate sets of 19 plots, including four "No Manure" check plots, situated in adjacent fields. The manurial treatments under investigation comprise varying rates of application of superphosphate (from 1 cwt. to 4 cwt. per acre), other phosphatic manures, nitrogenous manures, and potassic manures, with and without the addition of superphosphate, and superphosphate in addition to soil amendments such as lime and gypsum. For convenience and to test the consistency of the results, each plot is subdivided into nine sections.

One set of plots was closely mown during 1929–31 and the other set during 1931–33. In the seasons when either set was not being mown a meadow hay cut was taken off in late spring, and the plots were grazed by sheep for the remainder of the season.

Cutting pasture samples on the rotational grazing tests.

Conclusions.

(1) The results for four seasons showed that superphosphate was superior to all other manures or combinations of manure.

(2) Compared with "No Manure":—

1 cwt. super. per acre gave an increase of 47 per cent.
2 cwt. super. per acre gave an increase of 77 per cent.
3 cwt. super. per acre gave an increase of 100 per cent.
4 cwt. super. per acre gave an increase of 110 per cent.

(3) Irrigated pastures are extremely productive, the high average yield of 24½ tons of green clippings per acre being obtained over four seasons from the "4 cwt. super." plot.

(4) The limit of profitable application of super. has not been reached with 4 cwt. per acre.

(5) Compared with the increase of 77 per cent. achieved by a dressing of 2 cwt. of super. only:—

2 cwt. super. + Ammonium sulphate, 1 cwt., gave an increase of 48 per cent.
2 cwt. super. + Nitrate of Soda, 1 cwt., gave an increase of 54 per cent.
2 cwt. super. + Potassium sulphate, 1 cwt., gave an increase of 59 per cent.
2 cwt. super. + Lime, 30 cwt., gave an increase of 63 per cent.
2 cwt. super. + Gypsum, 30 cwt., gave an increase of 60 per cent.

(6) Other phosphatic fertilizers such as basic slag, and particularly rock phosphate, were much inferior to super., 2 cwt. per acre applications of these manures giving increases of 54 per cent. and 18 per cent. respectively.

(7) Nitrogenous and potassic manures without super. gave no better results than No Manure.

Chemical analyses have shown an enhanced feeding value from top-dressing these pastures with superphosphate, and the liberal use of this fertilizer permits sustained high production in the growing season, and promotes better growth in the winter period.

New Manurial Tests.—Mowing tests are being carried out on manurial plots arranged in two Latin Squares. These tests are complementary to the older series, and are designed to measure the results with greater accuracy. The plots have been mown during the past season 1933–34, and so far the results have confirmed the former findings.

Nitrogenous Manuring Tests.—During 1933–34, in a small area adjacent to the cow paddocks, a series of 48 plots has been mown at regular intervals. In this series there are four randomized blocks of 12 manurial treatments. A basal dressing of 2 cwt. super. is given throughout, then four plots receive an additional 2 cwt. per acre of super., and the remainder receive 1 cwt. or 2 cwt. per acre of ammonium sulphate each month from April to August inclusive (eight plots top-dressed per month).

The mowing of these plots will be continued during the season 1934–35, but, so far, no significant differences in total yield have been obtained. A response from the nitrogenous fertilizer is noted during July and August, but as growth is limited during this period, the increases obtained do not materially affect the total yield.

Frequency of Cutting Tests.—The plots are situated in the same area of 1½ acres as are the nitrogenous manuring tests. They are designed to determine the yields from pasture cut at varying intervals. Total yield of herbage is not the only measure of excellence, but chemical analyses of the herbage being carried out at each cut, due cognizance is taken of the yield of protein, fibre, silica-free ash, and carbohydrate plus fat. There are seven treatments, replicated six times in randomized blocks and the following are the total yields of mown herbage, reduced to dry matter from each plot (area, .045 acres) over a period of 48 weeks during the season 1933–34:—

Cut weekly, 313 lb.
Cut fortnightly, 360 lb.
Cut three-weekly, 376 lb.
Cut monthly, 392 lb.
Cut five-weekly, 420 lb.
Cut eight-weekly, 466 lb.
Cut for hay, and then three-weekly, 457 lb.

There are progressive and significant increases in yield from the weekly to the eight-weekly cuts, but no significant difference between the eight-weekly plots and those cut for hay in November and then cut every three weeks.

The major differences affecting the total yields of these plots occurred in the first 16 weeks period, from 29th August, 1933, to 19th December, 1933, which included the spring flush of growth. There was practically no difference in the aggregate yields from the different treatments for the remainder of the season.

As the chemical analyses of the herbage are not yet completed for these tests, it is impossible to indicate the best treatment from both yield and nutritive value of the herbage, but there is no doubt that the lower yields of the plots cut more frequently will be largely compensated for by the higher quality of the herbage from these plots.

Sheep and lambs on the rotational grazing tests.

Rotational Grazing Tests.

In 1929, a series of tests was commenced, a 10-acre paddock being subdivided to test the influence of two different systems of grazing on carrying capacity and condition of the pasture.

In one portion, 5 acres is divided into two, and each half is grazed alternately for ten days. The other portion of 5 acres is subdivided into ten ½-acre lots, and each of these is grazed for two days in rotation.

The pasture on the area is eighteen years old. Perennial Rye grass and Kentucky Blue grass were spread throughout, while Cocksfoot was fairly well represented. White clover, Strawberry clover, and Subterranean clover were well distributed. The manurial treatment was an autumn dressing of 2 cwt. of superphosphate. Before commencing the tests the whole area was grazed short.

From the commencement of the test the plots have been grazed by sheep, which are weighed at 10-day intervals.

For extended periods some plots have been yield-sampled and botanically surveyed before and after grazing, with a view to measuring the growth of herbage, the seasonal variation, the amount eaten by the sheep, and the preference of the sheep for particular species. The outstanding results have been—

(1) The extraordinarily high-carrying capacity of the pasture under both systems of rotational grazing, the ½-acre system having the advantage.

Year.	Sheep per Acre per Annum.		Type of Sheep.
	2½-acre Plots.	½-acre Plots.	
1930	10·8	13.3	2-tooth Lincoln x Merino wethers
1931	13·1	14.1	2-tooth Lincoln x Merino wethers (3 months), then crossbred ewe weaners
1932	13·1	13·8 + 18 lambs for 2 months	Rising 4-tooth Lincoln x Merino dry ewes
1933	11·4 + 8 lambs for 160 days	12·4 + 9.3 lambs for 160 days	4-tooth Lincoln x Merino lambing ewes

(2) There was a sustained high production of live-weight increase by the sheep throughout the duration of the tests as indicated in the following table:—

Year.	Lb. Live Weight Increase per Acre.	
	2½-acre Plots.	½-acre Plots.
1930	660	856
1931	721	595*
1932	436	550*
1933	879	926

* During these years, live-weight increases were reduced considerably through the incidence of pizzle-rot in the wethers and black disease and entero-toxæmia in the ewes. Also the ½-acre plots were severely punished by the adoption of a 10-day instead of a 20-day rotation during the greater part of these two seasons.

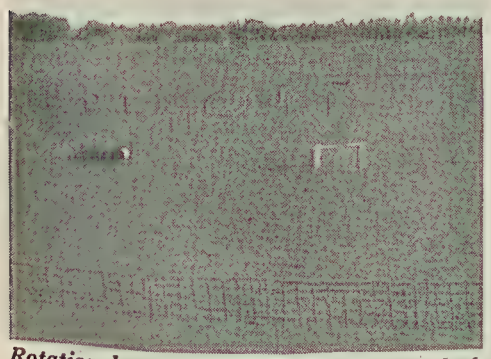
(3) Very good fleeces of clean, good quality crossbred wool were produced. The average fleece weights for the four years for both sections were :—

8½ lb. from the rising 4-tooth wethers in 1930,
5 lb. from the rising 2-tooth ewes in 1931,
10½ lb. from the rising 4-tooth ewes in 1932,
and
10¼ lb. from the 4-tooth ewes in 1933.

(4) There was a surprisingly high winter carrying capacity, never less than eight sheep per acre being carried on the ½-acre plots at this period. In the winter of 1933, eight ewes with lambs at foot were carried, and this performance has been repeated this year.

(5) Wethers or dry ewes do not make live weight increases for a period of 2½ months in the winter in the absence of supplementary feeding, but maintain their body weights or, at the worst, make slight losses. Pregnant ewes continue to make gains through the winter until they lamb down.

(6) Fat lambs can be bred and reared to prime condition under intensive grazing on this type of irrigated pasture. The lambs were an average age of 160 days when removed for sale, and were approximately 80 lb. in live weight at that age.



Rotational grazing trials, showing methods of subdivision and enclosure for sampling pasture.

(7) Except for the period when a 10-day rotation period was adopted on the ½-acre plots, the pasture itself did not deteriorate, and this is confirmed by the fact that during 1933 a higher carrying capacity was attained and that more live weight per acre was produced than during 1930.

Grazing Tests on Old Lucerne converted to Pasture.—A 10-acre field which formerly was reserved for lucerne experiments was scarified in 1931 and converted to pasture. This field was subdivided subsequently into four paddocks, and has been rotationally grazed in conjunction with the rotational grazing test field proper. It is intended that this field be used for carrying out experiments with supplementary feeding of sheep grazing on short herbage.

Prevention of Common Complaints of Sheep.

On intensively grazed irrigated pasture, where sheep are concentrated in large numbers on small areas, it may be expected that various complaints, which are only incidental to flocks in less favoured circumstances as regards feed, will be aggravated. Members of the veterinary staff of the Department have availed themselves of the opportunity provided by the grazing tests on the farm to study closely the effects of preventive medicine. By attention to drenching, parasitic worms and liver fluke infestation have been kept in check. Foot-rot has been successfully dealt with by periodically trimming the feet of the sheep and running them through a foot-bath containing a 5 per cent. copper sulphate solution. The regularity of the foot-bath treatment was assisted by the fact that the sheep were weighed every ten days, and could be kept in the foot-bath for some minutes before weighing. Vaccination for "black disease" and entero-toxæmia in both sheep and lambs has given very satisfactory results.

The time occupied and the relatively small expense incurred in the administering of preventive medicine were more than compensated for by the few losses of sheep and lambs sustained, when with less attention very considerable losses might be expected under intensive grazing on this type of pasture.

Variety and Strain Tests.—A large number of species and strains of species are grown and kept under observation in garden plots. The outstanding results have been the promise shown by acclimatized strains of grasses and clovers, which have become adapted to the conditions under which they are growing. The Swan Hill strain of strawberry clover, and various strains of white clover from the irrigation districts of the State are examples.

FARM LIVE STOCK.

Horses.

All the draught horses on the farm are pedigreed Clydesdales, and this stud, whose prefix is "Victoria," is well known throughout the Commonwealth. The high class sires "Major Oates," C.C.S.B. 285, "Baron Wigton," C.S.B. 13884, "Kitchener," C.C.S.B. 248, and "Widgiewa Norval," C.C.S.B. 956, have in turn been used at the head of the stud for the past twenty years. "Baron Belmont," "Craigie Masterstroke," "Flashdale," and "Baron's Favourite" also feature in the pedigrees of this stud.

"Flash Bute," C.C.S.B. 857, by "Flashdale," imp., ex "Silver Bute," by "Baron Bute," imp., was purchased in September, 1931, and has done service at stud at the farm for the past three seasons. Eleven two-year-old and fourteen yearlings by "Flash Bute" now on the farm show breeding, stamina, and quality to a marked degree. Approximately twenty farm-bred mares are showing in foal to "Flash Bute" this season.

A young Clydesdale sire.

For many years special attention has been given to raising good class pedigree Clydesdale colts for sale, and farmers in many parts of Victoria and other States are now using certified Clydesdale stallions bred at the Research Farm.

At present there are on the farm, in addition to the stud sire "Flash Bute," 33 mares, 17 fillies, 5 foals, 20 geldings, 12 two-year-old and yearling colts, and 2 three-year-old stallions, all of which were bred at the farm.

Flash Bute.

Sheep.

The farm flock of stud Suffolk sheep now totals 900, including the present season's crop of lambs. The chief features of this breed as borne out by experience on the farm are:—(*a*) Mutton producing qualities; (*b*) early maturity; (*c*) fat lamb raising qualities; (*d*) prolificacy. The average lambing of the stud flock for the past twenty years has been approximately 140 per cent. The farm has been successful in gaining many Champion and Reserve Championships with both ewes and rams at the Sheep-breeders' and Melbourne Royal Shows since the establishment of the flock in 1914.

Ten Ryeland ewes and two rams were imported from New Zealand in July, 1925, and this breed has proved suitable to conditions at Werribee.

Dairy Cattle.

Red Polls.

Red Poll cattle are recognized as the ideal dual purpose breed, combining heavy producing dairy qualities with excellent beef qualities. The breed, generally, is very contented, and does well under most conditions. The cows are easy and quiet to milk, and usually have shapely udders with teats of convenient size. The all red colour, absence of horns, the small fine quality bone, and the readiness with which the individuals fatten have made Red Polls very prominent in Australian beef markets. When prime, top prices are obtained for them.

The above characters have been borne out at the Research Farm, where the "Victoria" Red Poll stud has been developed by 24 years of line-breeding, the use of production-bred bulls, and the selection of high quality and high producing females as breeding stock. The results obtained have been highly satisfactory, for not only are the production records of the cows well up amongst those of cows belonging to one or other of the dairy breeds, but high prices are always obtained for cast for age cows sold as beef. The demand for stud stock—bull calves and females—has always exceeded the supply.

In the Standard Herd Test for 1933–34, one cow—Victoria War Ghost (dam, Victoria Ghenta) produced, in 273 days, 11,009 lb. milk, 4.57 per cent. test, 503 lb. butter-fat. In 365 days she produced 13,740 lb. milk, 4.54 per cent. test, 623 lb. butter-fat. She is the ninth Red Poll cow to produce over 500 lb. butter-fat in Victoria, while her 365-day record has been exceeded only by Muria (885 lb.) and Nictitana (658 lb.). Victoria Ghenta produced 620 lb. butter-fat in 365 days, and 496 lb. butter-fat in 273 days.

Victoria War Ghost.

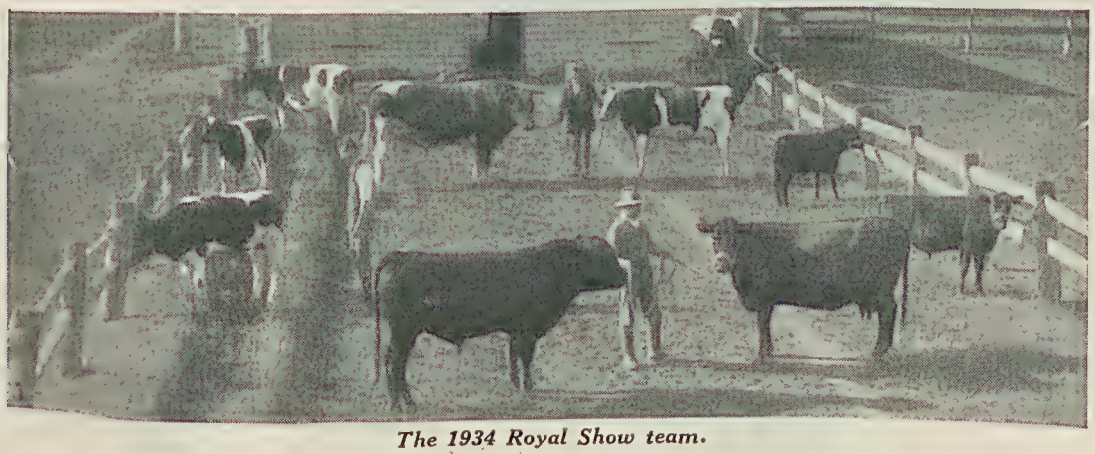
The average production of the herd over the past seven years is shown in the accompanying table :—

Production, Red Poll Herd since 1927–28.

Year.	Number of Cows in Test.	Milk.	Test.	Butter-fat.	Butter-fat lb. with Allowances for Heifers.
		lb.	%	lb.	
1927–28 ..	42	6,911	4·55	314·61	411·21
1928–29 ..	41	8,547	4·23	361·85	418·33
1929–30 ..	34	8,782	4·40	381·99	443·11
1930–31 ..	41	7,781	4·41	338·11	442·75
1931–32 ..	37	7,342	4·45	323·79	399·31*
1932–33 ..	41	6,954	4·56	315·02	388·69*
1933–34 ..	39	6,868	4·59	313·13	387·40*
Average for seven years, 275 cows..		7,575	4·44	334·59	412·87

* In 1931–32 the allowances for heifers were reduced. Under the old scale these averages would have been 413.63 lb., 402.35 lb., and 400.99 lb.

Woodburn Peter Pan, imp. in utero (A.A., Vol. 7), whose dam produced 15,672 lb. milk 4.61 per cent. test, 723 lb. butter-fat in 273 days under Association test, was purchased as a



The 1934 Royal Show team.

Woodburn Peter Pan.

yearling in July, 1933. The use of Woodburn Peter Pan is the first introduction of outside blood into the "Victoria" stud for twenty years. Already seven promising calves have been born to this sire.

The senior Red Poll herd sire is Dominion Bright Belgian, who was imported from New Zealand in July, 1929, and who is descended from stock originally exported from the Victoria stud in 1918. Dominion Bright Belgian was Royal Champion at Christchurch in 1927, and at Palmerston North in 1928, and Reserve Royal Champion at Auckland, New Zealand, in 1926.

The other herd sire is Victoria Gallant (AA. Vol. 7) from Victoria Village Belle, who was the second highest producing cow in the stud last year, producing 458 lb. butter-fat in 273 days, and 579 lb. butter-fat in 365 days.

A very promising yearling sire—Victoria Goblin (Sire: Victoria Brilliance from Nictitana. Dam: Victoria War Ghost), was put to service this season.

The Victoria Friesian Stud.

The sixteen-year old "Victoria" stud has been built up along high production lines from stock imported from New Zealand, that carries much Woodcrest Jo, de Kol, and Mercedes blood. The average production of this herd has always been well up in the averages of the Standard Herd Test. This year 15 cows and heifers produced an average of 11,891 lb. milk, 3·61 per cent. test, 427 lb. butter-fat, and 496 lb. butter-fat with allowances for heifers. The herd gained thirteenth place in the list of averages for butter-fat production but easily led for milk production, and the milk was above the standard of 3.5 per cent. required by the health regulations for the whole-milk trade in Victoria.

Dominion Bright Belgian.

The Friesian herd sire is Victoria Joyous Mercedes (985), Champion in 1931 and Reserve Champion in 1928 and 1929 at the Melbourne Royal Show. Victoria Joybell, the dam of this bull, produced, in 273 days, 15,387 lb. milk. 3·67 test, and 565 lb. butter-fat on twice-a-day milking. The first seven daughters of this sire to complete their lactations in the Standard Herd Test averaged 9,895 lb. milk, 3·72 per cent. test, 367 lb. butter-

Victoria Reparation—540 lb. butter-fat in 273 days.

Victoria Joyous Mercedes, leading herd sire in Victoria Friesian stud, and some of his daughters.

fat on their first lactations. His oldest heifer—Victoria Joyous Piebe—produced 538 lb. butter-fat as a mature cow and 500 lb. as a senior-4-year old.

The average production of the herd during the past seven years is set out in the accompanying table.

Average Production of Friesian Herd since 1927–28.

Year.	Number of Cows in Test.	Milk	Test.	Butter-fat.	Butter-fat lb. with allowances for Heifers.
		lb.	%	lb.	
1927–28	14	9,177	3·67	336·85	399·21
1928–29	10	13,644	3·41	465·24	512·74
1929–30	10	11,831	3·40	399·45	456·95
1930–31	13	12,763	3·43	431·92	500·01
1931–32	10	10,116	3·69	369·00	417·00*
1932–33	10	10,512	3·65	378·03	434·03
Average for six years 67 cows		11,275	3·52	394·63	457·11

* In 1931–32 the allowances for heifers were reduced. Under the old scale these averages would have 429.00 and 448.53 lb. respectively.

The other herd sires are Victoria Double Top (1354), a grandson of Victoria Lean Patch, and Victoria Woodcrest Jo (Vol. 13), by Victoria Joyous Mercedes from Victoria Patchwork, who twice produced 528 lb. butter fat on twice-a-day milking.

It is customary to sell the bull calves of both breeds on the basis of 1s. per lb. of butter-fat produced by the dam in her best lactation. Surplus females also are sold from time to time at prices ranging up to 30 gns.

During the past year Red Poll bull calves were distributed over all sections of Victoria, and to New South Wales, Queensland, South Australia and Western Australia. The sales of Friesians were chiefly to the Western District and Northern Victoria.

Victoria Songbelle—576 lb. butter-fat; Champion Friesian cow, Melbourne Show, 1929.

POULTRY.

The poultry flock at Werribee is accommodated in up-to-date houses, comprising 24 breeding pens, 130 pens for single testing and experimental work, a brooder house (60 feet x 15 feet) heated with hot-water pipes, a chicken-house (60 feet x 15 feet), a laying shed to accommodate 450 hens, shed to accommodate 500 pullets for feed experiments, feed-room and grain silos, store-room, workshop, egg-room, office, and incubator room with incubator capacity for 1,800 eggs.

The Leghorn stud consists of 150 birds, all of which have been bred from tested stock. Their quality is denoted by the fact that the official record for six white Leghorn hens for twelve months' laying is held by a team bred from a setting of eggs from this flock. These six birds laid 1,699 eggs at the Burnley competition, and were afterwards sold for £75. At the Burnley competition 1931–32, the winner in the Single Test, Wet Mash Section, laid 337 eggs (all first grade) in 365 days. This is an official record for a White Leghorn for Victoria. This bird, as well as the Second Prize Team in the Dry Mash Section, was owned by Mr. J. L. Edgcumbe, Plenty. They were all bred from stock procured from the State Research Farm, Werribee.

The Australorps consist of a stud flock of 150 birds, also bred from tested stock. Many of them are of the same line of blood as the team that won the 1922–23 Burnley competition. This team laid 1,602 eggs for the twelve months, and also established an official world's record for winter test by laying 579 eggs in 122 days. Mr. S. E. Barker's team of Australorps which won the winter test at the Burnley competition last year were bred from stock procured from this farm.

Approximately 1,500 birds are now being used for breeding experiments, feeding experiments, and for egg production.

Poultry Feeding Tests.

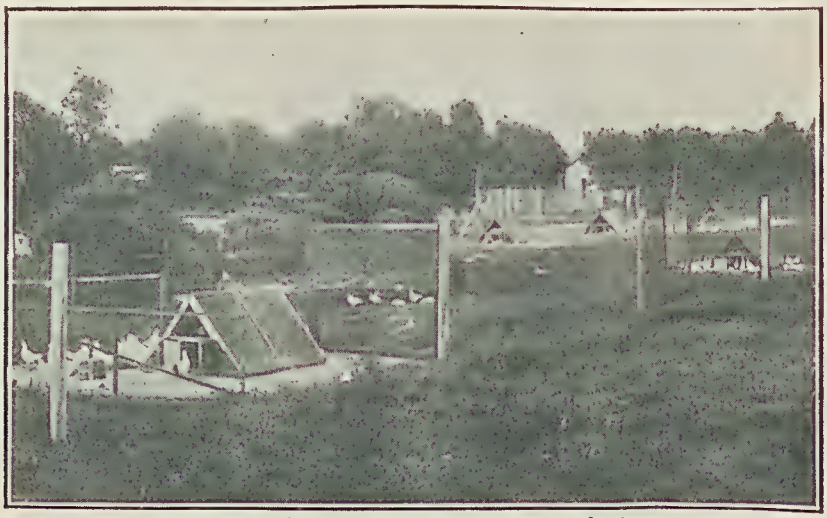
Extending over the eleven months from the 1st May, 1933, to the 31st March, 1934, several poultry feeding tests were conducted.

For the purposes of the tests 500 pullets were selected, consisting of 250 White Leghorns, which were divided into five pens of 50 each, and 250 Australorps, similarly divided. The Australorps averaged 164.3 eggs per bird; the White Leghorns 160.8 per bird. The average wholesale price for eggs during the test was 1s. 0¼d.

The cost of food, based on the ruling wholesale price for the different foodstuffs, amounted to 3.7d. per dozen eggs laid; the cost per bird per week was 1.05d.; the quantity consumed per bird per day was 3.5 oz., and for every egg laid 7.1 oz.

The gross profit, or the profit over food cost, was 9s. 7½d. per bird. This figure shows that, notwithstanding the poor price of eggs, there was a fair margin of profit; this was made possible by the low cost of food.

These tests, as well as many others that have been conducted at Werribee during the last thirteen years, have demonstrated that when feeding pullets for egg-production, satisfactory results can be obtained from rations varying considerably in composition.



The colony system at the State Research Farm.

The Valencia Late Orange in Victoria

By

J. L. Provan, B.Agr.Sc., Horticultural Research Officer.

Valencia Late orange trees, 24 years old, worked on sour orange stock.

OF all the seed orange varieties grown commercially in Victoria the Valencia Late is the most popular. The Valencia, as it is so frequently called, achieves this distinction because of the high quality of its fruit which ripens after the Navel orange crop is harvested. The late maturity of this variety extends the orange season through the summer months, and, in addition, provides a good supply of fruit during the months of October and November when there is a comparative scarcity of other classes of fruit. In South Africa and California the Valencia orange is grown extensively, and is now practically the only seed orange recognized as a commercial possibility.

Its keeping qualities, together with its maturity period during October and November, make it a very desirable fruit for the export trade, especially to the British markets where supplies of oranges are not so plentiful during these two months, and if we are to succeed in establishing an overseas market we must pay particular attention to this variety. Nearly all growers in Victoria plant a portion of their grove to the Valencia Late orange, and the large, upright and vigorously growing trees can be readily distinguished from the flat and pendulous habit of the Washington Navel trees.

A peculiar habit of seed oranges generally is their tendency to be alternate croppers, i.e., they yield a particularly heavy crop one year and practically nothing the next, and the Valencia, unfortunately, also possesses this disadvantage.

The Valencia orange is characterized by its medium size and slightly oval shape, with a pale orange-coloured rind which deepens a little as maturity advances. The rind is smooth, or of a slightly pebbled texture, and is thin but tough; after keeping for a little while it assumes a leathery texture, which resists the development of moulds and so lengthens its storage life. The juice is plentiful and sub-acid in flavour; this variety usually having a higher acidity and therefore a more citric flavour than the Washington Navel. Although the Valencia is classed as a seed orange, very frequently samples will possess only 2 or 3 seeds and sometimes they may be quite seedless. The Valencia orange, like the Navel, is parthenocarpic, i.e., the tree is able to set fruit without pollination, and indeed pollination seldom results in a heavier crop, but only assists the formation of seeds in fruit which would otherwise be practically seedless. This explains, why in some cases, growers who have mixed groves find that their Valencia oranges are more seedy than those of their neighbours.

Soil and climate also have their effects on the seedlessness or otherwise of the fruit, and it has been observed frequently that trees which were isolated produced abundant seeds, due chiefly to the climatic and soil conditions favouring the development of viable pollen. In this respect the Valencia is comparable with the Washington Navel orange and the Eureka lemon, the flowers of which frequently contain no pollen and yet set heavy crops of fruit.

Citrus grove of Mr. T. W. Wenham, Wangaratta.

ORIGIN OF THE VALENCIA LATE.

At this stage it may be interesting to review briefly the history of this popular orange. It originated apparently in the Azores, and Thomas Rivers, an English nurseryman, imported and catalogued it in 1865 under the name "Excelsior." In 1870, an American nurseryman named Parsons bought several trees from Rivers and planted them in his nursery at Florida. E. H. Hart, of Federal Point, Florida, obtained trees from Parsons and popularized the variety, and it became known as Hart's Late or Hart's Tardiff, and the name Excelsior joined the list of forgotten fruit varieties. Oranges from these trees were exhibited in Florida in 1877.

California obtained the "Excelsior" from two sources. About 1870–72, Chapman, of San Gabriel, imported a number of varieties from the English nurseryman Rivers, and several Californian nurserymen introduced Hart's Late or Hart's Tardiff, as it was then called, from Florida. In the collection of trees imported by Chapman there was one tree wrongly labelled "Navel." This turned out to be a late orange, and a Spanish labourer named the tree "Valencia Late." When it was discovered that the two varieties were identical the now well-known name, "Valencia Late," was adopted.

The earliest introduction of any variety of orange to Australia was due to the foresight of the Chaplain, the Rev. Richard Johnson, who accompanied the "First Fleet" under Capt. Arthur Phillip in 1787. Mr. Johnson obtained seeds at Rio de Janeiro, and on arrival sowed them at Kissing Point, New South Wales. It is recorded that these trees produced fruit which was sold for as much as one shilling each. It is quite likely that one of the Chaffey Bros., of Mildura, was responsible for introducing the Valencia to Victoria, as well as to the Murray districts of South Australia. In 1888, one of the Chaffey Bros., probably Charles, brought out from California two Washington Navel and two Valencia Late trees which were given to Mr. William Chaffey, of Mildura. The Washington Navel was already being grown in New South Wales, but at this period records of the Valencia are wanting.

To what age will an orange tree live? This is a question which is very difficult to answer. In Spain it is recorded that there is a tree over 150 years old. The oldest Victorian orange grove must be that of Mr. T. W. Wenham, of Wangaratta. This grove originally comprised 20 acres of Parramatta seedlings, and was planted by Mr. Bryan in 1864. In California there is a

A Valencia Late orange budded on to a Beauty of Glen Retreat Mandarin. Note: The fringe of the Mandarin remains until growth from the buds is established.

five-acre grove of Valencia Late oranges now 54 years old, and still in an excellent state of health and productivity; some of the trees have a trunk diameter of 64 inches, and yield as much as 33 bushels of fruit. In Mildura there are several small groves of Valencia Late oranges which are nearly 40 years old, and these trees produce fine crops of good quality fruit.

The Valencia may be harvested during October and November, when it ripens, or it may hang on the tree until March or April, and supply the demand for oranges during the summer months, when incidentally prices are more favorable to the grower. In many groves and districts, however, the Valencia orange, after it has obtained full maturity and colour, will revert to the green colour, although internally the fruit is perfectly ripe. From a marketing stand-point this colour change is undesirable and growers usually adopt one of two alternatives; they either market the fruit before the colour change occurs, or they treat the fruit, after it has reverted, with suitable concentrations of ethylene gas in gas-tight chambers under favorable temperature and humidity conditions. Fruit so treated for a period of two or three days has the orange colour restored. There is a good deal of speculation as to whether this colour change is a characteristic of one strain of Valencia or whether it is due solely to the root stock and environment. A series of experiments commenced two years ago at Mildura will assist in solving this problem. These experiments chiefly consist of collecting buds from as many sources as possible, in order to include what appear to be numerous types or strains of the Valencia orange, and budding them on to old trees in order to place them in the same environment. By this means the effects of soil differences and cultural treatments on the quality of the fruit will be eliminated and responses to seasonal conditions can be studied.

Alternate Bearing of the Valencia Orange.

Further remarks on the alternate bearing of the Valencia are necessary. It cannot be expected that the trees each year should yield crops equal to the heavy crop, nor would it be possible to induce trees to yield so heavily. The solution appears to be in the direction of encouraging a lighter crop in the year in which the heavy setting is expected and a larger crop in the following year. In so many Valencia groves at present the trees during the heavy crop year undergo such a severe depletion of stored food products that little or no fruit is produced the following year. This depletion is so severe that frequently the trees show only very small amounts of blossom.

The new type of cultivator.

In order to overcome this habit several practices suggest themselves as being worthy of trial. The principal one, of course, would be a judicious thinning of the newly set fruit in the season when the heavy crop is expected. This thinning is an essential feature of many peach, apricot, and mandarin plantations, and, although costly, it is worthy of a trial in Valencia orange production. Heavier fertilizer applications during the heavy crop year may also improve the crop in the succeeding year.

Pruning of citrus trees is a much neglected practice in Victorian citriculture, and it is certainly one which repays the time so spent. When possible, pruning should be completed before growth commences in the spring. The year of the light crop is an opportune time for pruning the Valencia, and the best month is August. An alternative system is that of pruning after the heavy crop has set, say, in November; but such a pruning, although it may remove some of the newly set fruit cannot be regarded as having entirely the same effect on the tree as thinning the actual fruit. With pruning, some leaves as well as fruit must be removed, and this is the reason why growers, who prune with the intention of thinning the crop in order to increase the individual size of the fruit are often disappointed. If fruit and leaves are removed, little alteration in size of fruits will be noticed; but if fruit only is removed, then the leaves are enabled to provide storage material for the remaining fruit. Pruning should consist of "skirting" the trees until all limbs within a foot to eighteen inches of the ground have been removed, and the cutting out of unwanted watershoots, crossing limbs, diseased and dead wood, and a judicious thinning of the foliage where it has become too dense. The Valencia seldom bears fruit in the centre of the tree, and therefore thinning, on similar lines to Navel orange tree pruning, is not warranted.

The control of Red Scale on Valencia orange trees is a particular difficulty in some localities, because the matured and the developing fruits are hanging side by side. Growers who experience this difficulty are advised to adopt the dual or combination program, i.e., fumigation, followed later in the season by a white oil spray wherever the infestation is heavy.

Re-working and Root-stocks.

With regard to reworking other varieties of citrus trees to the Valencia Late variety it may be mentioned that departmental experiments have been quite successful with oranges, lemons, and mandarins, and many hundreds of trees have now been rebudded with Valencias.

The question of root-stocks for Valencias, as well as many of the factors influencing the quality of the fruit, has been dealt with at length in this *Journal* for October, 1934. Generally speaking, the Valencia Late orange, even when budded on the rough lemon root-stock, is a hardier tree than the Washington Navel orange. The Valencia has been more successful than the Washington Navel in the Goulburn Valley districts, where it produces particularly heavy crops.

A recent development in the cultivation and irrigation of citrus groves is the introduction of a disc cultivator having one set of discs extended laterally and protected by a metal cover so that it can pass under the fringe of foliage without damaging the fruit or branches, which merely brush over the cover. In this way the soil beneath the trees can be lightly cultivated and weed growth suppressed. By means of an additional attachment an irrigation furrow can be made beneath the trees. With large trees, and particularly Valencia Late trees, which do not possess the same tendency for the branches to reach to the soil level as does the Washington Navel, this implement is valuable for increasing the fertility of the soil beneath the trees. One grower by manuring, cultivating, and irrigating this soil succeeded in doubling his yield.

Float arranged by the Department of Agriculture for the floral pageant held in Melbourne on 26th October in connection with the Victorian Centenary celebrations. The float shows Ceres, the goddess of Agriculture, with a representation of the pastoral, agricultural, and horticultural wealth of the State.

Echuca Irrigated Pasture Competition

Report of the Judge—E. T. Beruldsen, B.Sc. (Agric.), Senior Irrigation Officer

THE establishment of mixed pastures under irrigation, in the Echuca district is a comparatively recent practice. Consequently, it is pleasing to record the general excellence of the exhibits in this the inaugural competition organized by the local Agricultural and Pastoral Society. Altogether there were eight entries, but judging from the keen interest shown, a greater number of entries is expected next year.

The efficacy of top-dressing with superphosphate was demonstrated amply in the case of two of the exhibits which actually had not been sown down, but in which white clover, subterranean clover, perennial rye-grass, and paspalum had appeared as volunteer growth, completely replacing thinned-out lucerne stands. One of the paddocks referred to, exhibited by Mr. A. E. Patman, had been graded and sown down with 8 lb. of lucerne and 2 lb. of red clover more than ten years ago. Mr. Patman uses superphosphate liberally, and during the ten years never less than 2 cwt., and sometimes over 3 cwt. of this manure per acre had been applied annually. When the lucerne thinned out after four or five years the volunteer white clover, a very robust strain, had already made its appearance, and together with paspalum and a free-seeding strain of perennial rye-grass formed a very fine sward of pasture. Lucerne, subterranean clover, and red clover were also represented in the pasture. The excellent condition of Mr. Patman's fine herd of dairy cows was also a tribute to the quality of his pastures.

The remaining self-sown pasture was exhibited by Mr. F. C. Gilham, and here also a very vigorous strain of white clover had replaced lucerne which was sown down eight years ago. Mr. Gilham has been applying one bag of superphosphate per acre to the area each year. Although the mixture was rather unbalanced, the only other species present being short-lived perennial and annual strains of rye-grass, and a few plants of subterranean clover, there was no denying the quality and quantity of feed present and the evidence of very high carrying capacity. In the past, Mr. Gilham's cows have acquitted themselves very creditably in the local herd test, and he asserts that the grazing off of this pasture always coincided with a marked increase in the butter-fat percentage of his herd.

A very vigorous strain of strawberry clover was observed on the property of Mr. R. Height. This strain was similar in structure and habit of growth to the Swan Hill and Myall strains of this species, and also to a strain from Palestine now under the observation of the Agrostology Branch at Burnley Gardens.

The appearance and rapid development of these strains of valuable legumes in the various irrigation districts have always been associated with the liberal use of superphosphate and adequate watering. Farmers should exploit these better strains and hasten their development artificially by transplanting runners and collecting and sowing seed.

It was noticed that in nearly all cases the exhibitors had appreciated the necessity for sowing the best persistent strains of perennial rye-grass. Certified Hawke's Bay perennial rye-grass or the

A productive irrigated pasture.

strain guaranteed by the Colac Rye-grass Growers' Association had been sown generally.

The attention of the competitors is directed to the necessity for careful preparation and grading of the land. In one or two instances the bays were rather wide. Two-thirds of a chain is the maximum width recommended, even in fairly level country. In nearly all cases the check-banks were not substantial enough, and on one farm they consisted merely of plough furrows. When it is remembered that pastures of this nature should last indefinitely and improve with age, and that the continual tramping of stock tends to obliterate the check-banks, the necessity for having them substantial in the first instance should be realized.

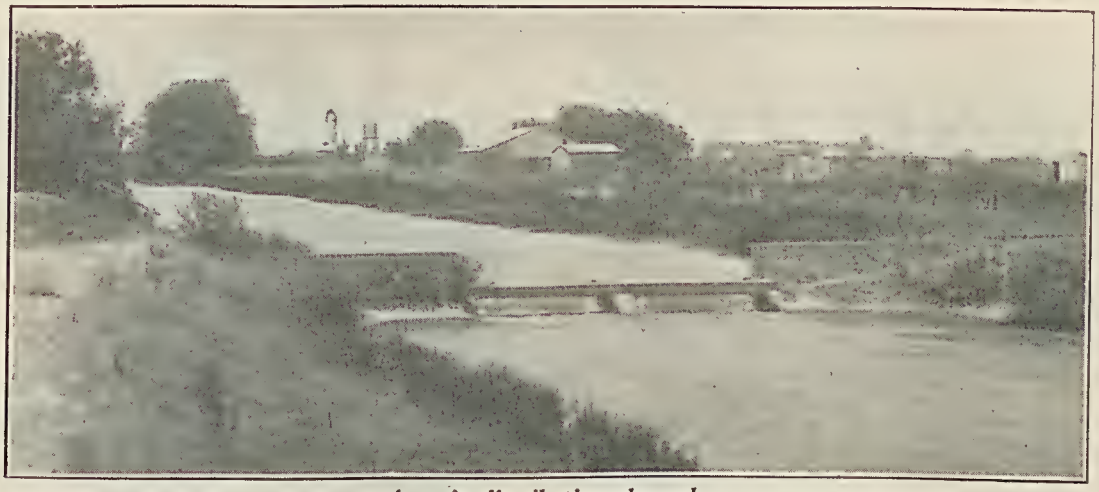
A good permanent pasture mixture with perennial rye-grass, cocksfoot, and white clover predominating.

The absence of subterranean clover from the sown mixtures was a feature of each exhibit. This was due probably to the fear that this species might take possession, thus excluding the white clover, but when the pasture is regularly and adequately watered, white clover responds and keeps subterranean clover in restraint. The presence of subterranean clover in the mixture certainly is advantageous in increasing the winter production of a mixed pasture.

The winning pasture, exhibited by Mr. G. W. Dobson, was sown down on fallow in April, 1933. It consisted of 5 acres seeded to Colac perennial rye-grass 2 lb., Italian rye-grass 3 lb., cocksfoot 2 lb., and 2 lb. each of perennial red, alsike, and New Zealand wild white clovers per acre mixed with superphosphate at the rate of 90 lb. per acre. The pasture was top-dressed again with 80 lb. of superphosphate per acre in April of this year. The ground is rather stiff plain land bordering the timber country, and does not absorb water readily. This necessitated frequent irrigations during the summer, fortnightly intervals elapsing between waterings. The pasture had been leniently treated as regards grazing during the winter, and at the time of inspection presented an excellent sward in which all the species sown were well represented, white clover and perennial rye-grass being the most prominent features. Cocksfoot, which normally is not a conspicuous feature of a young pasture, was developing satisfactorily. It is not often that so dense a sward is obtained in such a comparatively young pasture, and evidently Mr. Dobson had

ECHUCA IRRIGATED PASTURE COMPETITION, 1934.

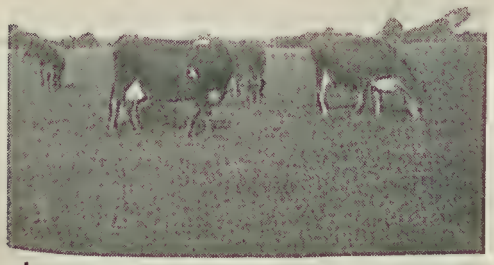
Name of Competitor.	Lay-out of Ground for Irrigation and Condition of Channels.	Condition of the Pasture.	Uniformity.	Mixture.	Freedom from Weeds.	Total.
Possible Points	**20**	**20**	**20**	**20**	**20**	**100**
1. Dobson, G. W.	19	19	18	19	19	94
2. Christie, D. G. M.	18	19	17	19	19	92
3. Gilham, F. C.	18	19	19	16	18	90
4. O'Neill, J.	19	18	16	17	18	88
5. Patman, A. E., Exhibit No. 2	18	18	16	18	17	87
6. Patman, A. E., Exhibit No. 1	19	17	15	17	17	85
Height, R.	18	17	16	16	18	85
Paynter, S. E.	17	17	16	17	18	85



A main distributing channel

paid close attention to the watering. The herbage was in fresh condition and just at the proper stage of growth for grazing off with dairy cattle. Apart from a few small patches of rank growth, and a small patch at the bottom of two of the bays which had not developed so strongly the uniformity was very good. Except for a little cape weed, which is easily noticeable at this time of the year, weeds were negligible.

The runner up, Mr. D. G. M. Christie, exhibited a pasture of four acres sown down in April, 1932. Hawke's Bay perennial rye-grass was sown at the rate of 15 lb. per acre, and 2 lb. of Kentucky blue grass was included instead of Italian rye-grass. Otherwise, the mixture was essentially the same as that of Mr. Dobson's. At seeding 2¼ cwt. of superphosphate per acre was applied, and an average of 2 cwt. per acre has been added each year since. The watering method was essentially the same as for the winning pasture.



A portion of Mr. D. G. Christie's pasture.

Although the bays were rather wide, this was not so disadvantageous in such flat land, and very excellent provision for drainage was present. Perennial rye-grass and white clover were prominent, and with the exception of Kentucky blue grass the other species were well represented. The condition was very good and the growth fairly uniform. Apart from a few thistles and docks, weeds were not prominent.

Mr. Christie adopts the system of rotational grazing, and aims at spelling his paddocks for about three weeks and grazing them for about a week. As evidence of the high carrying capacity of the pasture exhibited, it is well worth recording that at one period last summer it took a fortnight for 19 cows to graze off the paddock.

The other competitors are to be complimented on the quality of their exhibits. Most of the pastures had been established only recently, and they showed promise that with more attention to watering and manuring they would develop into very find swards. A most interesting feature of the tour was a 45-acre paddock of luxuriant subterranean clover, on the property of Mr. S. E. Paynter. It was established four years ago by sowing 1 lb. of seed with a crop of oats, and demonstrated the value of this pasture type in extensive areas where water supply might be restricted in the summer. By the judicious application of early autumn and late spring irrigations, green feed can be obtained for eight months of the year.

Fowl Pox

By R. N. Johnstone, B.V.Sc., Superintendant of Live Stock.

FOWL pox is one of the commonest diseases affecting the adult fowl, and is the cause of heavy annual loss to the poultry industry throughout the world. It is a contagious disease due to a filter passing virus, and is characterized by pustules on the bare portions of the head, by yellow cheesy membranes in the mouth or by a discharge from the eyes and nose. Any one, or a combination of these lesions may be present in one bird or in one outbreak. Occasionally in an outbreak one form may predominate, and this fact gave rise to the opinion held in the past that these were the symptoms of separate and distinct diseases which were variously described as chicken pox, contagious epithelioma, avian diphtheria, roup, diphtheritic roup, or canker. However, as the lesions on the skin and those in the mouth are merely different manifestations of the same disease caused by the same filterable virus, it is obviously incorrect to give them different designations.

Fowl pox is very common in Victoria. The number of outbreaks varies from year to year, and while cases occur in all seasons the disease is frequently more prevalent in summer and autumn. Fowls and turkeys are especially susceptible to infection, but it is occasionally found in ducks and geese. Pigeons also are susceptible, but in them the virus undergoes modification. This has a special significance, which will be referred to when dealing with control.

Susceptibility of Disease.

All breeds of fowls are equally susceptible to infection, but under natural conditions those with large combs are more frequently affected, probably because of the greater area of bare skin exposed.

Fowls of all ages are susceptible, but in practice it is found tht the disease usually makes its appearance amongst young hens when they are placed in the laying pens, and then spreads very rapidly. Outbreaks among young chickens or in birds over a year old are not common.

Fowl pox lesions on the comb, the wattles, and the corners of the mouth.

Mode of Transmission.

The natural method of propagation probably is through wound infection. Small wounds are frequently present on the head, as a result of the continuous pecking and fighting which occurs among a flock; wounds or abrasions of the mouth also occur probably through eating grit. Burnet has shown that giving virus in the drinking water over a period of one month failed to infect a pigeon, but when sharp grit was fed with the virus the disease occurred, presumably as a result of infection through a wound of the tissues.

The rapidity of the spread of fowl pox from pen to pen through a flock, however, was a source of much controversy until various

investigators conclusively demonstrated that mosquitoes can transmit the virus of the disease. Kligler proved the transmission from affected fowls to healthy ones kept in separate cages in one room, and mosquitoes found in fowl-houses have been found to carry the virus on the mouth parts. The virus is confined to the proboscis of the mosquito, and does not enter its body, although the insects are capable of transmitting the disease fourteen days after taking up the infectious material. It is interesting to know that prior to this discovery Bice reported his success in rearing fowls free from infection in screened enclosures.

Once the disease is introduced to a pen there is no doubt that transmission from bird to bird takes place without the intervention of the mosquito, and that wounds on the head and in the mouth afford a portal of entry, but the appearance of the disease in flocks reared on clean ground and in new buildings may be reasonably explained by the action of the mosquito as a carrier and transmitter of the virus.

Numerous experiments have been carried out by Doyle and Minett in England to determine if fowls which have survived an attack of the diesease may act as carriers. These experiments indicate that the virus does not persist on the combs after the lesions have healed, nor could it be recovered from the blood or organs. The experiments therefor produced no evidence in favour of the existence of carrier birds, and field experience supports the conclusion that if carriers exist they are extremely rare and of little importance in the dissemination of the disease.

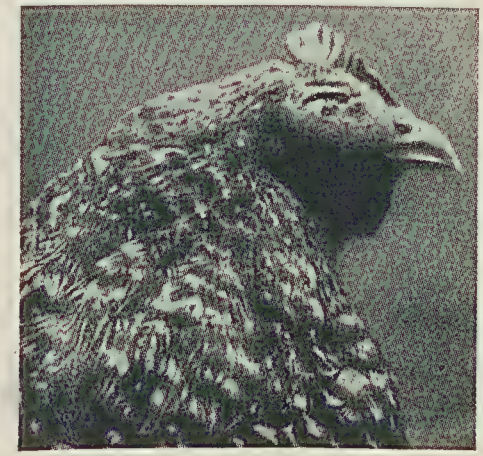
Symptoms.

The period which elapses between infection and the development of symptoms varies from three to twelve days, being influenced by the strength of the virus and the resistance of the birds attacked.

For the sake of convenience the symptoms of three clinical forms are described:—

(1) *Oculo-nasal Form.*—The first symptoms are dullness, loss of appetite, and occasional sneezing. These are followed by the development of a watery discharge from the eyes and nose. The eyes become inflamed and swollen, and the eyelids tend to stick together with the tenacious exudate. The nasal discharge becomes thick. The face frequently becomes swollen on one or both sides; this is produced by the accumulation of the thick cheesy exudate in the facial sinuses. The cleft in the palate may become closed with the caseous material, interfering with the normal passage of air, and giving rise to mouth breathing.

(2) *Diphtheritic Form.*—In addition to the dullness and loss of appetite, this form may commence with an occasional hard cough. An inflammatory condition of the mucosa or membrane of the mouth and pharynx then develops, followed by the formation of diphtheritic membranes. These deposits commence in the form of greyish-white plaques on the mucosa, which gradually extend and coalesce until the whole of the buccal cavity and mouth may be involved.



Swelling of the face in fowl pox.

The false membranes are dirty greyish or yellowish, tough and tenacious, and removed with difficulty from the underlying mucosa. When detached, they leave the underlying surface raw and inflamed, but it is rapidly covered by new membranes. The formation of the diphtheritic material frequently extends to the larynx and trachea, and sudden deaths of fowls during an outbreak of fowl pox may often be ascribed to the suffocation following the complete obstruction of the passage of air through the larynx by the diphtheritic deposits.

The absorption of toxic products from the lesions results in diarrhoea and emaciation, and death soon follows. A marked characteristic of the diphtheritic form of fowl pox is the nauseating smell which emanates from the mouths of affected birds. During the mouth breathing which may occur in this form

of the disease, the tip of the tongue tends to become dried with the unusual passage of air through the mouth, and may appear hard and contracted. This condition is frequently referred to as the "Pip."

(3) *Cutaneous Lesions.*—These are usually found on the skin of the head, the comb and wattles, but may be seen also on the parts of the body incompletely covered with feathers. The lesions at first consist of reddish-grey papules which gradually enlarge to become nodules, firm, rough and wart-like growths yellowish in colour at first and gradually becoming darker until, in old lesions, they consist of black scabs. The lesions show a tendency to coalesce with the formation of yellowish to black scabs covering the comb and wattles. If forcibly removed, the underlying skin is exposed as a raw bleeding surface.

When the cutaneous form appears alone, little disturbance of general health accompanies the infection, and recovery takes place without treatment in a fortnight to a month after the development of the lesions. In a number of cases, however, the cutaneous type is succeeded by the mouth lesions, frequently seen in experimentally inoculated birds.

It must not be thought that the three types of lesions encountered in fowl pox are distinct entities. All three forms may not be found in the same bird, but an examination of the individual fowls in an infected flock usually will show the presence of the three types, although at different seasons of the year there appears to be a tendency to follow particular form to predominate.

The oculo-nasal form may be accomplished by loss of sight, which prevents the bird from finding its food, and death takes place from starvation.

Post-mortem Appearances.

In fowl pox, the lesions are confined to the skin, and mucous membranes of the eye, nose, mouth, pharynx and upper respiratory tract. No lesions are to be found in the viscera.

Treatment.

As fowl pox is a contagious disease, and as individual fowls are of relatively small value, it is advisable to kill those affected. Early discovery and destruction of affected fowls may prevent the further spread of the disease, but if the first cases are ignored, infection spreads gradually until finally the runs become grossly infected, the disease intensifies, and usually causes heavy mortality. In view of the contagious nature of the disease, the risk of an extensive outbreak, and the time and expense involved in the frequent dressing of affected birds, it must be recognized that treatment is both scientifically and economically unsound. As with all contagious diseases affecting livestock, the rational method of control is by prevention.

Immunity.—Although there is a considerable variation in the degree of individual susceptibility to fowl pox, few birds possess a natural immunity. The degree of immunity developing after natural infection varies according to the severity of the attack—a mild form giving only a partial immunity, while a severe attack produces a well marked and solid immunity.

A solid immunity can also be produced by inoculation with a modified virus. It is essential that the vaccine should be alive but reduced in virulence to such an extent that while a definite reaction is given, the disease itself is not set up by the vaccination. Numerous attempts to produce a vaccine which will answer these requirements have been made with varying success. Recently Dr. Seddon, of the Glenfield Research Institute, New South Wales, has prepared a vaccine which, up to date, appears to be reasonably safe, and to produce a solid immunity. Although it has been shown that the virus of fowl pox, and that of pigeon pox are immunologically undistinguishable, pigeons show a marked resistance to fowl pox virus, while pigeon pox virus will set up a local lesion in the fowl, but does not cause a general infection nor death. Fourteen days after inoculation with pigeon pox virus, fowls which gave a definite reaction were found to be solidly immunised against natural infection and partially protected against artificial infection with fowl pox virus. Susceptible fowls do not contract infection when kept in contact with fowls exhibiting active pigeon pox lesions resulting from vaccination. The vaccine does not give rise to any constitutional disturbance, loss of condition or, so far as has been ascertained, interfere with egg production.

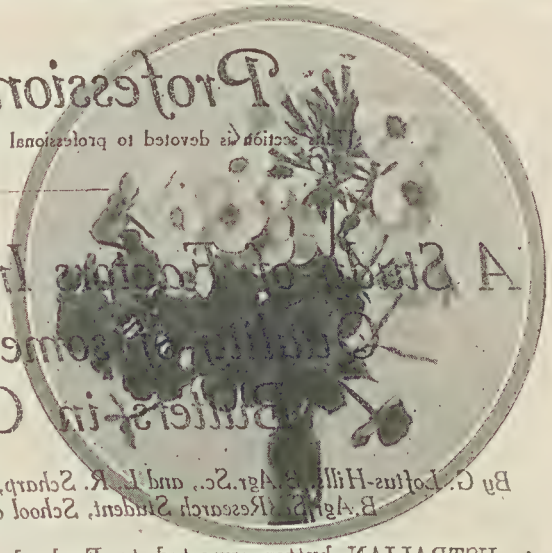
Since the original work by Doyle and Minett on pigeon pox vaccination was made known, research workers in other countries have secured similar results, and it can now be definitely stated that pigeon pox virus will protect fowls against a natural infection with fowl pox. Employed in conjunction with

[*Continued on page 600.*

Orchard and Garden

Notes

By Edward E. Pescott, F.L.S.



Phlox Drummondi.

The Flower Garden.

EXTENSIVE plantings should be made of summer and autumn flowering annuals, such as Aster, Marigold, Zinnia, Phlox and similar plants. These plantings will be the final ones for the year. If Aster wilt has been experienced in previous years—a wilt which also affects Zinnias, Stock, and Wallflowers—the soil should be well sprinkled with copper carbonate before planting. Lime must be avoided for these annuals.

The Liliput Zinnia should not be neglected. This dainty long-flowering annual gives a wealth of blossom for many weeks. If there is room, a row or two of the Dahlia-flowered Zinnia, planted at the back of these, will make a brilliant display in the borders.

Before describing the details of the tall-growing African Marigolds should be planted in the garden for autumn flowering. This annual grows to a height of 6 feet, and flowers through autumn, winter, and early spring. But the best for giving cut flowers are the Dahlias. These should be staked and from the end of the month will require to be watered. Staking is absolutely necessary for the plants are very brittle, and cannot withstand the early autumn winds. A Three new varieties are well worth growing. Gold Tips is a decorative variety, clear vivid red in colour, the tips being bordered with gold. The stems are stiff and strong. Mrs. J. B. Cannon is a clear yellow variety with quilled and pointed petals and strong rigid stems. It is a giant cactus. In Grace Stewart is also a good cactus dahlia, still-stemmed and of a rich rose pink. These three varieties were grown last season at the Burnley Horticultural Gardens, and all received awards at the flower shows.

The Orchard.

The summary of the Codling Moth report issued last month shows the moth can be controlled by the use of arsenate of lead in the early sprays and white oil in the last two sprays. This, also, is the only spray schedule in which the arsenical residues were below the prescribed limit.

AUSTRALIAN butter exported to England is necessarily subjected to about six months' cold storage, during which time it undergoes certain changes. These changes affect all the factors likely to affect the keeping quality of butter, so that butter after being in cold storage for some months is not the same butter as before it was put into cold storage. Victorian butter exported to England is subjected to about six months' cold storage, during which time it undergoes certain changes. These changes affect all the factors likely to affect the keeping quality of butter, so that butter after being in cold storage for some months is not the same butter as before it was put into cold storage.

Spraying should be very generally carried out. All trees should be banded with the chemical bands and lures should be used so that an indication may be obtained as to the correct time to spray.

Woolly aphis should be attacked at the present time. If there is no aphelinus in the district, application should be made to the Department of Agriculture for a supply. It is only in those districts where the parasite is at work that the white fluff is blown away, the black appearance of the aphis being the only indication of its presence. This parasite is less marked than in the English market.

The Vegetable Garden.

In order to obtain strong, succulent vegetables it is necessary to keep them well fed and very well watered. Sometimes in the vegetable growing areas, especially in hot weather, it will be seen that the vegetables are grown amidst semi-swamp conditions. It is thus that a very quick return is provided for. All vegetables, therefore, should be grown in well-enriched soil and given ample water.

At this season of the year garden pests are usually prevalent. Slugs, snails and slaters should be dealt with by sprinkling bran and calcium arsenate about the beds. This mixture must not be used in the form of baits, as in that form it will be eaten by birds and domestic animals. After the preparation is mixed and it should be mixed as dry as possible it should be loosely scattered over the garden beds.

Pea mite is kept in check by giving the beds a dusting of pestend and lime in equal quantities.

Professional Papers

[This section is devoted to professional papers and articles of a scientific character.]

A Study of Factors Influencing the Keeping Quality of some Victorian Salted Butters in Cold Storage[1]

By G. Loftus-Hills, B.Agr.Sc., and L. R. Scharp, B.Agr.Sc., Dairy Technologists, and T. S. Bellair, B.Agr.Sc. Research Student, School of Agriculture, University of Melbourne.[2]

AUSTRALIAN butter exported to England is necessarily subjected to about six weeks' cold storage before it reaches the consuming market. Its ability to maintain its quality in cold storage is therefore a matter of considerable economic importance for the Australian dairying industry.

As a result of a gradual modification of butter factory practice in directions shown by experience to yield the best results, Australian butter has attained a high standard of keeping quality. The butter, however, possesses a flavour which is less marked than that sought by a large section of the English market.

In order to determine whether a stronger flavour could be used without loss of keeping quality, and because cases of deterioration during shipment still occur, it was decided to investigate the factors which control the keeping quality of the butter. Numerous investigations in other parts of the world have shown that there are many factors which may be concerned. The investigation therefore became a matter of determining which of these known causes were important under the local conditions of manufacture.

Seventy Victorian butter factories co-operated in the work by each placing a box of butter at our disposal for three months. These butters were graded by certificated graders and sampled. Export butter is graded into three classes; "Choicest" with 92 points or more, "First grade" with 89 to 91 points, and "Second grade" with 88 points or less. These numbers have an empirical significance only. Most Victorian butters grade between 90 and 93 points. The samples were subjected to an extensive chemical and bacteriological examination designed to embrace all the factors likely to affect the keeping quality.

The boxes of butter were stored at about 12° F.[3] After three months they were removed, regraded, and again sampled, the samples being examined by the same methods as before.

Before describing the details of the experiment, a *résumé* of the methods of butter manufacture generally used in Victoria may be of value to those who are not familiar with them. The butter is manufactured in factories with an annual output ranging from 100 to 2,000 tons. In the summer the cream from each supplier is generally delivered every two days, the acidity of the bulk cream at the factory being about 0·4 per cent. expressed as lactic acid. In the winter the cream delivery may be as infrequent as twice a week, the acidity measuring as low as about 0·18 per cent.

The cream is graded, and "neutralized," most frequently with sodium bicarbonate. An acidity of about 0.15 per cent. lactic acid is aimed at. The cream is then pasteurized. In most factories flash pasteurizers have replaced the batch type, as they have been found to give a distinct improvement in quality. The temperature of pasteurization averages 190–195° F. The cream is shock-cooled to about 40° F. and held at that temperature overnight.

Where batch pasteurizers are still used, the cream is generally heated to about 155° F. for half an hour. Bacteriological surveys of butter factories have shown that pasteurization is

[1] This paper was published in the *Journal of Dairy Research*; [2] T. S. Bellair, B.Agr. Sc., is now employed by the Australian Sunny South Services Ltd. as Dairy Technologist. [3] Butter sent to England is held at about this temperature in the ship's hold.

generally very efficient, the count of flash pasteurized cream on lactose agar being usually below 100 colonies per c.c. The cream is churned at about 46° F., washed, dry-salted with about 1.5 per cent. salt, worked to the correct moisture content, and boxed immediately.

In the present investigation the butters were received in four groups at intervals of a few days. Their ages at the time of grading and sampling ranged from two to eight days, averaging six days. Appreciable bacterial contamination from the triers used for grading and sampling was prevented by the following treatment:

They were immersed in washing solution (soap and caustic soda) at 200° F. for 2 minutes, in clean water at 200° F. for 1 minute, and then cooled under running tap water (300 organisms per c.c. on gelatine). They were then thoroughly dried with autoclaved sanitary paper. The triers were made of chromium or nickel-plated steel.

Two samples were taken from each box. A large sample of about 200 g. was placed in a screw-top glass jar which had been rinsed with glass-distilled water and sterilized. A smaller sample intended only for chemical work was placed in a screw-top glass jar which had been rinsed with glass-distilled water and thoroughly dried. The samples were examined either within a few hours or after a few days' storage at 5° F.

The large samples were melted at 40° C. for the bacteriological examinations and the catalase test (Knudsen's method). They were then held at 55° C. to allow the serum to separate from the fat. The serum was used for the catalase determination by an application of the method of Zaykowsky and Aleksejeff, and for the determination of titratable acidity and pH; the fat was used for peroxide and acidity determinations. The smaller sample was used for total analysis, for determination of water-soluble titratable acidity and for copper and iron determination.

Bacteriological Investigation.

The following quantitative bacteriological tests were made on each butter before and after storage:—

Total count on lactose agar (pH 6·8) at 37° C.
Total count on gelatine (pH 7·3) at 21° C.
Liquefiers on gelatine.
Yeasts on wort agar (pH 3·5).
Moulds on wort agar.
Acid and/or gas producers in neutral red.
Lactose broth (pH 6·8) by 1/100 and 1/1,000 c.c.
Coliform organisms by gas production in peptone bile lactose gentian-violet broth (pH 7·8), using 0·1 c.c. of butter.

The predominating organisms in each sample were examined microscopically.

Results.—Total bacterial counts before storage ranged from 100 to 1,600,000 organisms per c.c. The distribution of the counts is indicated in Table I. The average counts before storage for the butters in each grade are expressed in Table II.

Table I.—Bacteria, Yeast and Mould Counts Before Storage.

No. of Butters.	Agar Plate Count.	Gelatine Plate Count.		Yeast and Mould Count.
		Total.	Liquefiers.	
14	Up to 2,000	Up to 2,000	Up to 100	Up to 10
14	2,000–5,000	2,000–15,000	200–500	10–30
13	5,000–10,000	15,000–25,000	600–3,000	30–100
14	10,000–20,000	25,000–60,000	3,000–10,000	100–200
14	More than 20,000	More than 60,000	More than 10,000	More than 200

Table II.—Relationship Between Grade and Bacterial Count Before Storage.

Grade.	Average Agar Plate Count.
Choicest	12,000
First	26,000
Second	5,200

The change in count during storage was very variable. The average ratios are given in Table III. In general the lactose agar counts decreased, while the gelatine plate counts and the yeasts increased. Coliform organisms and acid and gas formers disappeared during storage in some of the samples, but appeared in others.

In removing the butters from storage, one-half of the boxes were allowed four days in which to thaw while the other half were sampled after only two days at room temperature. The influence of this on the observed counts after storage is shown in Table III.

The lack of relationship between the change of grade during storage and the original gelatine plate counts is expressed in Table IV. Similar negative results were obtained in comparing lactose agar counts, liquefiers, yeasts and moulds, and coliform organisms with the change in grade. The predominating morphological types revealed by microscopic examination of Gram-stained preparations did not appear to affect keeping quality. Comparison of change in grade and change in bacterial counts during storage also showed no correlation.

Plate III.

Lactose Agar Plate with 0·01 cc. Butter showing 450 colonies.

Bacteriological Counts.

(Counts are expressed as colonies per cc.)

	Count.
Total count on lactose agar (pH 6·8) at 37° C.	15,000
Total count on gelatine (pH 7·3) at 21° C.	80,000
Lipolytic organisms (colonies). (All Streptococci except 1 colony.)	100
Yeasts on wort agar (pH 3·3).	1,000
Moulds on wort agar (pH 3·3).	Nil.

Plate IV.

Lactose Agar Plate with 0·01 cc. Butter showing 800 colonies.

(Mixed flora).

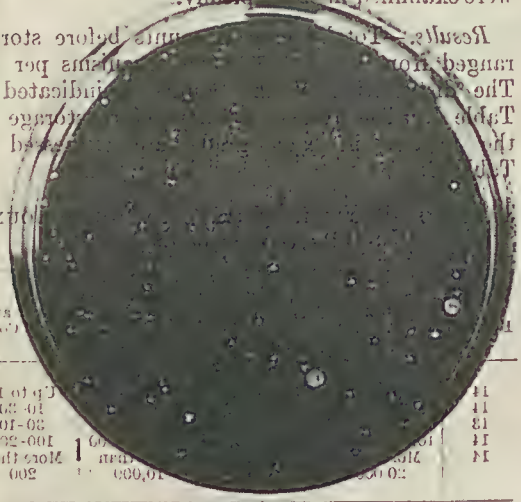


Plate I.

Gelatine Plate with 0·01 cc. Butter, showing 110 colonies (2 liquefiers).

	Total Count.	Liquefiers.
More than 10,000	More than 10,000	2

(The cloudy zones indicate where liquefaction of the gelatine has occurred).

Plate II.

Gelatine Plate with 0·01 cc. Butter showing almost complete liquefaction of plate.

	Total Count.	Liquefiers.
More than 10,000	More than 10,000	More than 10,000

Discussion.—Shutt (1) found that efficient pasteurization and freedom from recontamination were important factors in controlling the keeping quality of butter stored for six months at 10° F., while Macy and Ritchie (2) also claimed that, as a group, butters with low yeast and mould counts kept better at 5° to 10° F. than butters with high yeast and mould counts. Most investigators have concluded, however, that total bacterial, yeast and mould counts are not dominant factors in controlling the keeping quality of butter stored at temperatures below 32° F. The results of the present experiments confirm this opinion.

The bacterial counts of the butters before storage were not closely related to the grades of the butters. The dominant factor in determining the future of the butter so soon after manufacture would be the quality of the raw cream.

TABLE III.—RATIO OF TOTAL COUNTS AFTER STORAGE TO TOTAL COUNTS BEFORE STORAGE.

Samples.	Agar Plate.	Gelatine Plate.	Yeast and Mould.
All butters	0·82	2·0	1·5
Butters No. 1 to No. 37 ..	0·99	4·0	2·7
Butters No. 38 to No. 71 ..	0·71	1·2	2·7

Butters No. 1 to No. 37 were allowed four days at room temperature to thaw before being placed in storage, while No. 38 to No. 71 were allowed only two days.

TABLE IV.—RELATIONSHIP BETWEEN CHANGE OF GRADE AND TOTAL BACTERIAL COUNTS ON GELATINE BEFORE STORAGE.

| Change in Grade during Storage. | Average Bacterial Counts before Storage. | | |

Results and Discussion.

No relationship was found between the loss of grade during storage and the catalase value as determined by either method. This is shown in Table V.

TABLE V.—RELATIONSHIP BETWEEN CATALASE VALUES AND CHANGE IN GRADE DURING STORAGE.

Change in Grade (Points).	Average Catalase Value, c.c. Oxygen Evolved.	Average Catalase Value by Titration c.c. $KMnO_4$.
1	1·7	0·39
0	2·8	0·70
−1	2·2	0·39
−2	1·9	0·46
−3	4·9	0·65
−4	..	0·34

This result is, of course, in accordance with the finding of the bacteriological examination. It appears to provide interesting information on the importance of enzyme activity in causing deterioration in cold storage. The value of the test for catalase rests on the assumption that the enzyme is destroyed by efficient pasteurization of the cream. If any catalase is found, pasteurization must have been inefficient or recontamination with catalase-producing organisms must have occurred.

It seems reasonable, therefore, to conclude that where much catalase is present there will also be relatively large amounts of deleterious enzymes. The fact that tests for catalase were negative suggests therefore that enzyme action was not an important factor in the deterioration of the butter. In this connexion the figures in Table VI. are of interest. Many investigators of butter deterioration in cold storage have suggested that it is largely influenced by the quality of the raw cream from which the butter is made, possibly as a result of enzyme activity. The general experience with Australian butter shipped overseas, and the results shown above, are in direct opposition to this, since the higher grade butters are found to deteriorate more than the lower grades. This does not, of course, necessarily imply that the amount of chemical change occurring in the lower grade butters is actually smaller, since a given amount of change will probably be less apparent when the butter is already flavoured to some extent.

CHEMICAL INVESTIGATIONS.

The following chemical determinations were made on the butter, fat, or serum :—

(1) Complete analysis for moisture, salt, curd, and fat by the Kohman method.

(2) Water-soluble titratable acidity (5).

(3) Ether-soluble titratable acidity of the fat (6).

(4) pH (7).

(5) Peroxide value of the fat (8, 9). Two grams of fat were used. The results are expressed as c.c. N/500 $Na_2S_2O_3$ per gram of fat.

(6) Copper (10, 11, 12).

(7) Iron (10, 11, 12).

TABLE VI.

Original Grade.	Number of Butters Changing in Grade (Points).						Average Change in Grade (Points).	No. of Butters.
	1	0	−1	−2	−3	−4		
92 and more ..	0	12	14	5	0	1	0·88	32
90 and 91 ..	3	11	14	3	1	0	0·63	32
Less than 90 ..	1	1	0	1	0	0	0·33	3

Results.

The results obtained for the various determinations before storage are briefly expressed in Table VII.

TABLE VII.—SUMMARY OF RESULTS OF CHEMICAL DETERMINATIONS BEFORE STORAGE.

Determination.	Mean.	Standard Deviation.	Minimum.	Maximum.
pH	6·51	0·55	5·37	7·68
Titratable acidity of butter	0·015 %	0·007 %	Alkaline	0·050 %
Titratable acidity of serum	0·062 %	0·044 %	Alkaline	0·250 %
Peroxide value (Lea) ..	0·70	0·25	0·25	1·75
Copper ..	0·46 p.p.m.	0·16 p.p.m.	0·36 p.p.m.	0·58 p.p.m.
Iron ..	0·28 p.p.m.	0·11 p.p.m.	0·18 p.p.m.	0·52 p.p.m.
Acidity of fat..	0·59	0·10	0·26	0·66
Moisture ..	15·63 %	0·65 %	13·12 %	16·77 %
Salt	1·65 %	0·38 %	0·79 %	2·71 %
Curd ..	0·79 %	0·19 %	0·40 %	1·20 %
Fat	82·05 %	1·1 %	80·05 %	85·02 %

Discussion.

Complete Analysis.—No relationship was found between curd content, salt content, or brine concentration and keeping quality; or between brine concentration and bacterial increase or decrease.

Peroxide Value.—The work of Lea and others, has suggested that the peroxide value would be a useful indication of the tendency of butter to develop tallowy flavours. It was hoped that comparison of the peroxide values of these butters before and after storage would provide information

on this point, since several of the butters were described by the graders as tallowy or oily. Unfortunately the peroxide values of the fats obtained before storage were of little or no value. The fats were held for a week or so in a fairly well-lighted room before the determinations could be made. Subsequent experiments showed that fat held under such conditions increased considerably in peroxide value. After storage the peroxide values were determined within a few hours of melting the butter for bacteriological analysis. The figures were generally about half the value obtained before storage.

It is interesting to note that there was a positive correlation coefficient of 0·55 between peroxide value and pH of the butter before storage, compared with 0·27 after storage. In spite of the removal of the serum the acidity of the butter was apparently a controlling factor in determining the development of peroxide in the week during which the fats were held before examination.

After storage, eight butters were described as slightly tallowy. The average peroxide value of these was 0·40 and the range 0·27 to 0·69. The average for the remainder of the butters was 0·31 and the range 0·07 to 0·62. In view of the variation in individual samples the difference is not significant.

Copper and Iron.—In several of the factories which supplied butter for the experiment, areas of copper were exposed on the pasteurizer, pipe lines or vats. Where it was expected that the metallic content of the butter would be high, copper and iron determinations were carried out. Thirteen of the samples were examined in this way. The copper content ranged from 0·36 to 0·58, averaging 0·46 part per million. The iron content ranged from 0·18 to 0·52, averaging 0·28 part per million.

Although it is impossible to form definite conclusions from the small number of samples examined the results in Table VIII. indicate that these variations in copper content may possibly have a significant effect on the keeping quality of the butter. Results obtained since this experiment indicate that small differences in copper content, say 0.3 part per million, as for instance, between 0.4 and 0.7 part per million, are sufficient to account for considerable changes in quality between the time of manufacture of the butter and its arrival at the grading floor. With such appreciable changes occurring during this short period, two to three days at approximately 40° F., it seems likely that copper, or an associated factor, is important in influencing the keeping quality of butter during cold storage.

Table VIII.—Relationship Between Copper Content, pH Value, and Change in Grade of Butter.

Copper (p.p.m.).	Change in Grade (Points).	pH.
0·36	1	6·9
0·36	0	6·4
0·38	0	6·3
0·38	− 1	6·4
0·42	1	6·4
0·48	0	7·5
0·48	− 1	6·7
0·50	− 1	6·3
0·52	− 1	6·2
0·52	− 2	6·4
0·56	− 1	7·0
0·58	− 2½	5·6

Acidity of the Fat.—Determinations of the acidity of the fat were carried out on 24 of the butters before storage. Very little variation was found—the average value being 0.59, the standard deviation 0.10, and the extremes 0.26 and 0.66. The butters examined after storage did not differ markedly from these. There were apparent decreases in some instances and slight increases in others. The average was 0.48, the standard deviation 0.12, and the extremes 0.26 and 0.71. None of the butters was described as rancid after storage. It would appear that fat hydrolysis was a negligible effect in the deterioration of the butters under observation.

Titratable Acidity of the Butter, pH and Titratable Acidity of the Serum.—These three values were found to be closely related, the association between them being expressed in the scatter-diagrams shown in Figs. 2 and 3. In view of the slight variations found in fat acidity the close relationship between the acidity of the serum and that of the butter would be expected. The relationship between titratable acidity and pH is very much closer than that found by Nissen (5).

In contrast to Parfitt's (13) results, the butters almost invariably showed an increase in acidity during storage, this being reflected in each of the three measurements. There was only one exception to this in the pH measurements, five in the butter acidity, and three in the serum acidity. The changes in acidity, as determined by the three methods, did not, however, agree well. This was probably due to the small extent of the changes and the indefiniteness of the end-point in the titrations. The decrease in pH on storage averaged 0.16, the values ranging from an increase of 0.03 to a decrease of 0.62. As regards titratable acidity the figures were (*a*) for the butter, an average increase of 0.006 per cent., the values ranging from a decrease of 0.005 per cent. to an

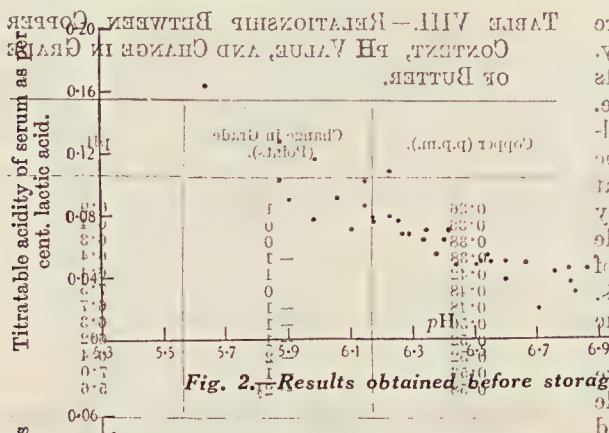


Fig. 2.—Results obtained before storage.

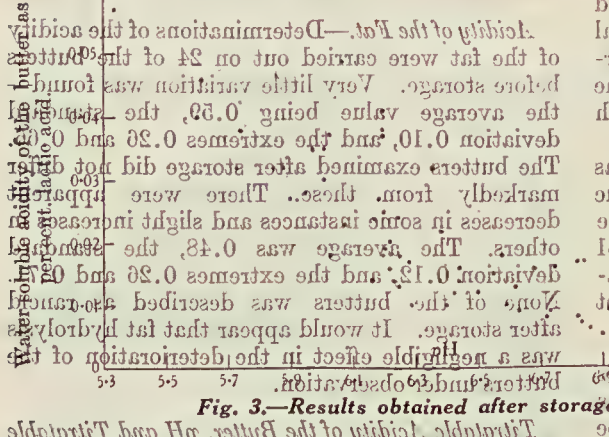


Fig. 3.—Results obtained after storage.

increase of 0.026 per cent., and (b) for the serum, an average gain of 0.010 per cent., the values ranging from a decrease of 0.009 per cent. to an increase of 0.040 per cent. The pH determinations provide the most reliable measurements. There was a distinct tendency for the pH of high pH butters to decrease more than that of the low pH butters. The change in acidity was not related to the change in grade.

Accuracy of Neutralization.—Information was obtained from the factories providing the butter as to the acidity aimed at in neutralizing the cream, the "neutralizer" used, and the type of pasteurizer employed. This information is presented graphically in relation to the pH of the butter in Fig. 4. It will be seen that butters made from cream supposed to be "neutralized" to the same acidity showed considerable variation in titratable acidity and pH. The assumption that "neutralization," as normally practised, enables an accurate control to be obtained over the acidity of the butter is obviously incorrect. We do not know whether these observed variations are due to errors of measurement in commercial practice, or whether they are due to inherent defects in the method of neutralization. Fig. 4 shows, however, that the variations may not be accounted for by the composition of the "neutralizer" or the type of pasteurizer used. Incidentally, it may be mentioned here that neither of these two factors affected the keeping quality of the butter.

Acidity and Keeping Quality.—The results shown in Table IX. indicate that, of the factors measured, the pH of the butter was the most important in controlling its keeping quality. Previous investigators of the subject have demonstrated the marked relationship which exists between acidity and keeping quality when butter has been made from cream of acidity greater than 0.25 per cent. expressed as lactic acid. The present results extend the range of that relationship to butters which are neutral or even slightly alkaline.

The variations in the behaviour of individual samples of butter, however, are considerable. These variations must be due to the combined effect of the inaccuracy of grading, the extent of which is unknown, and of other factors affecting the keeping quality, including factors not measured by the determinations made in this investigation. Efforts to correlate the variation in behaviour of butters of the same acidity with variations in bacterial

TABLE IX.—RELATIONSHIP BETWEEN pH OF THE BUTTER AND CHANGE OF GRADE AND INITIAL GRADE.

pH.	Approximate Titratable Acidity as Percentage Lactic Acid.	Average Change in Grade.	No. of Butters Changing in Grade (Points).					No. of Butters.	Average Initial Grade.
			−1 or more.	0	+1	+2	+3 or more.		
5·0–5·5	0·063	0·0	1	2	2	1	1	7	91·3
5·5–6·0	0·035	+0·4	4	11	3	1	0	19	91·4
6·0–6·5	0·020	+0·1	3	17	3	0	0	23	91·4
6·5–7·0	0·012	−0·1	4	7	1	0	0	12	91·4
7·0–7·5	0·005	−0·60	3	1	0	0	0	4	91·3
7·5–8·0	Alkaline	−0·00	2	8	1	0	0	11	91·3
			17	46	10	2	1	76	

With the exception of the erratic result for one butter in the pH range 5·0–5·5, there is a distinct association between pH and change of grade.

count gave negative results. Table VIII. is suggestive in that it indicates that the combined effect of acidity and copper content may be important in relation to keeping quality.

The manner in which acidity causes deterioration is not clear from the determinations made. Increase in the acid value of the fat showed no relation to pH, a fact which indicates that the butter acidity did not control deterioration through the mechanism of fat hydrolysis. Moreover, the pH values showed a very low correlation with peroxide after storage. If the peroxide value may be taken as a true indication of the extent of fat oxidation, this suggests that oxidation of the fat was not the cause of deterioration. The eight butters described as tallowy after storage did not show particularly low pH, their average value being 6.4, compared with 6.5 as the average for all the butters. Many of the butters showing deterioration were described as stale, and this gives no clue to the chemical changes which may have occurred.

Although this investigation was not primarily designed to give results directly applicable to the manufacturing process, but rather to provide basic information as a guide to future work, the results obtained do have some bearing on butter factory practice. They show fairly definitely that, in order to obtain the best keeping quality in cold storage, the butter should be at a pH of about 7. Butters of this acidity will, under normal methods of manufacture, have none of the desirable "lactic" flavour. The figures in Table IX. might be assumed to indicate that their flavour is just as good as that of the butters with higher acidity. The graders, however, knowing that acid butters will not keep, prefer a butter with no acid flavour, and their grading cannot therefore be taken as parallel with the judgment of that section of the English market which wants highly flavoured butter.

The extent to which flavour and keeping quality are incompatible has not been ascertained. The flavour of a good Danish butter can be attributed mainly to (1) the acidity, and (2) the presence of flavouring substances such as diacetyl and volatile acids. Although there is evidence that diacetyl is associated with fat deterioration, it seems unlikely that the volatile acids would be seriously detrimental to keeping quality. At any rate the practice in some Victorian factories has assumed that this is the case. They have attempted with considerable success, by various means such as ripening the cream and then neutralizing and pasteurizing it, to include the flavouring substances in the butter without the acidity. Butter made by such methods does not appear to meet the demands of the Danish butter-consuming section of the English market; it would seem reasonable to assume that the acidity is an essential part of their demand.

Some aspects of the present investigation would suggest that the problem of shipping an acid butter to England without loss of grade is not altogether a hopeless one. The variation in the behaviour of individual samples suggests that some factor other than acidity is concerned, and metallic contamination is probably one of the most important of these contributing factors. Many experiments on the subject, notably those of Grimes (14), indicate that other factors largely affect the extent to which acidity brings about deterioration. With further information as to the nature of these factors and means of controlling them, it may be possible to produce an acid butter with greatly improved keeping quality.

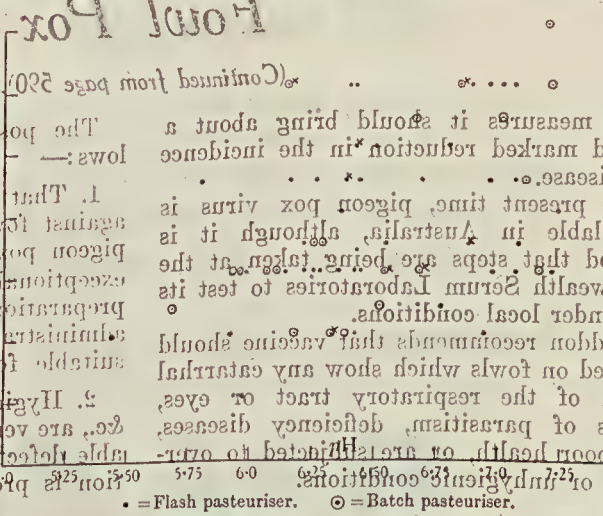


Fig. 4.—Relation between the pH value and the acidity aimed at in "neutralising" the cream, the "neutraliser" used, and the type of pasteuriser employed.

Summary.

Seventy boxes of salted Victorian butter were held at 12° F. for three months. Bacteriological and chemical examinations were carried out before

and after storage, in order to observe the changes which occurred and the factors which controlled deterioration.

The bacteriological examination showed that on the average only slight changes in bacterial numbers occurred during the actual cold storage period. None of the bacterial, yeast, or mould counts revealed any positive association with keeping quality.

The catalase test gave negative results. It is suggested that enzyme activity is not an important factor in controlling deterioration of the butters.

The chemical examinations indicated that the variations in curd or salt content did not affect keeping quality. Fat hydrolysis, as measured by ether soluble acidity of the fat, and fat oxidation as measured by peroxide value, did not appear to be important factors in deterioration. Considerable variations were observed in the acidity of butters made from cream supposed to be "neutralized" to the same acidity. Acidity of the butter as measured by titration of water-soluble material was closely related to the pH of the butter. Butter acidity and copper content appeared to be the most important factors controlling keeping quality. The mechanism by which acidity causes deterioration was not revealed by the investigation.

We desire to acknowledge the valuable assistance rendered in this work by Mr. W. J. Wiley of the Council for Scientific and Industrial Research.

Very similar work on the chemical and bacteriological factors affecting the keeping quality of butter in cold storage was carried out, at about the same time as that described in this paper, by Arup and Gilmour in Ireland. Most of their findings, particularly in connexion with the effect of bacteria and of acidity, show a striking parallelism to the results obtained here. Their work is reported in the *Journal* of the Department of Agriculture of the Irish Free State, vol. xxxii., No. 2, page 257.

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Fowl Pox

(*Continued from page* 590).

hygienic measures it should bring about a rapid and marked reduction in the incidence of the disease.

At the present time, pigeon pox virus is not available in Australia, although it is understood that steps are being taken at the Commonwealth Serum Laboratories to test its efficacy under local conditions.

Dr. Seddon recommends that vaccine should not be used on fowls which show any catarrhal condition of the respiratory tract or eyes, symptoms of parasitism, deficiency diseases, general poor health, or are subjected to overcrowding or unhygienic conditions.

The position may be summarized as follows:—

1. That is is possible to immunize fowls against fowl pox either by fowl pox virus or pigeon pox virus. When the former is used, exceptional care must be taken both in the preparation of the vaccine and the method of administration, and the selection of flocks suitable for vaccination.

2. Hygienic conditions, feeding conditions, &c., are very important factors, and any noticeable defects should be rectified before vaccination is proceeded with.

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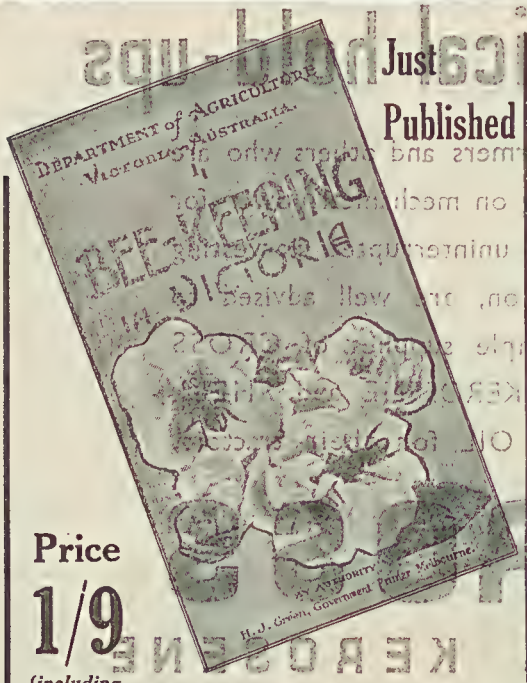

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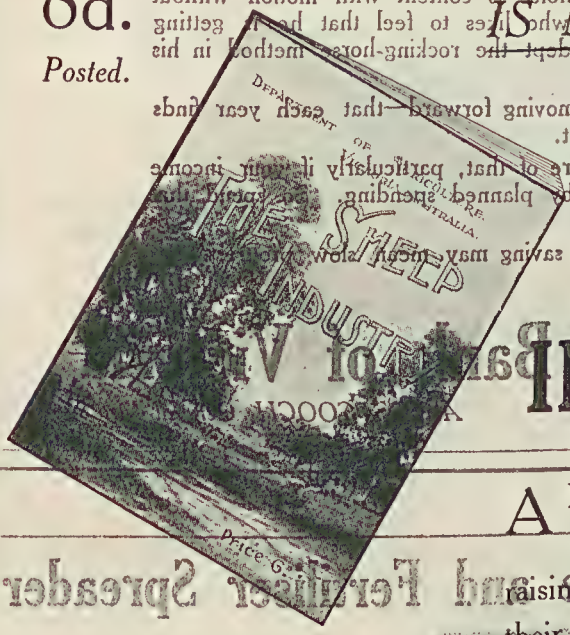

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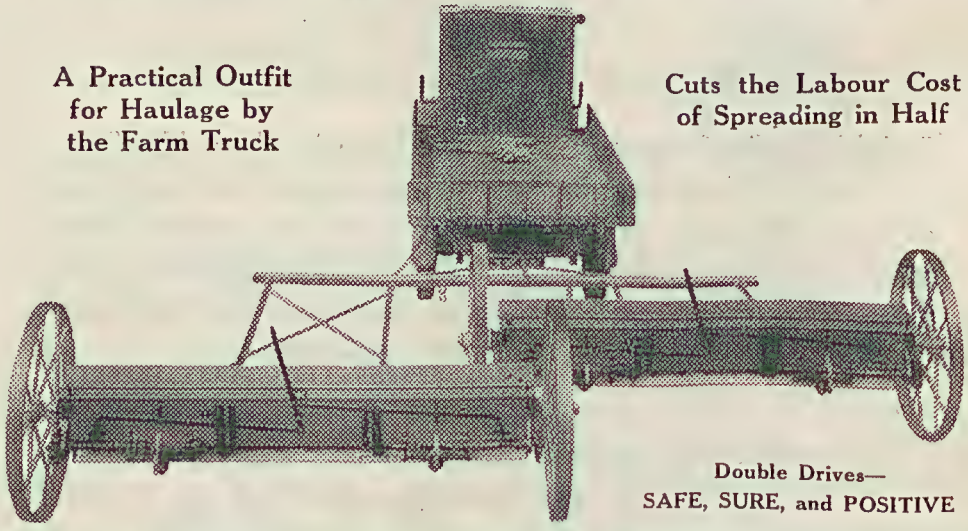

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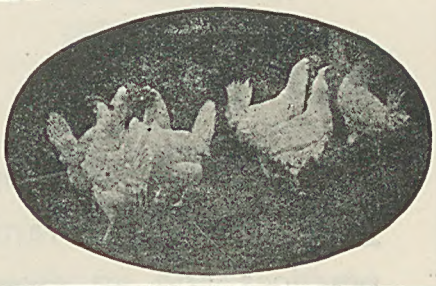

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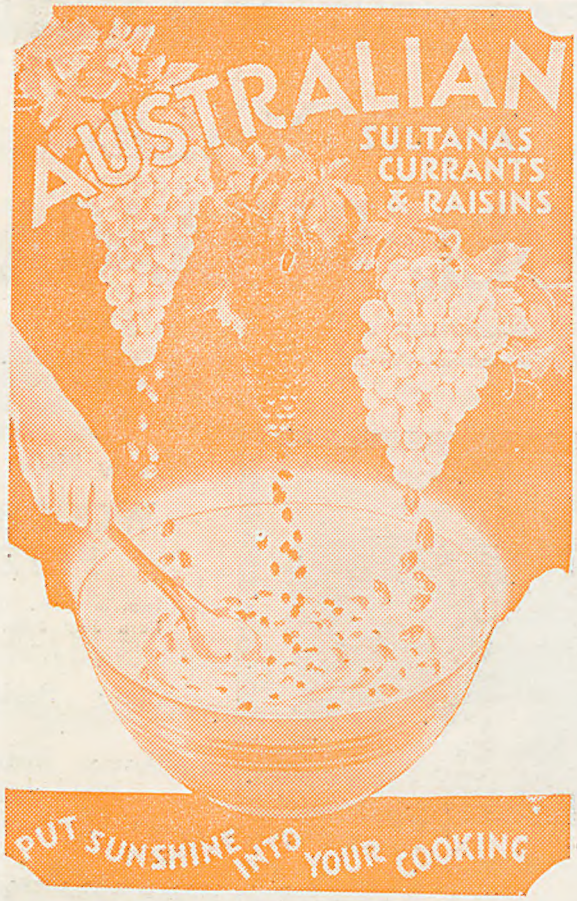

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